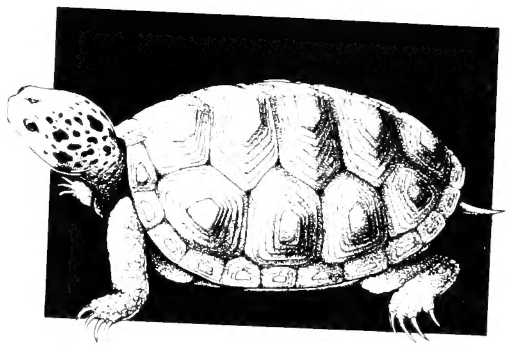

Bryan Patterson

A HISTORY

OF

BRITISH FOSSIL REPTILES.

BY

SIR RICHARD OWEN, K.C.B., F.R.S., Etc.,

FOREIGN ASSOCIATE OF THE INSTITUTE OF FRANCE (ACADEMY OF SCIENCES).

VOL. I.

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ERRATA.

Vol. I., p. 200.—The genus *Polyptychodon* was found to belong to the order *Sauropterygia:* see p. 455.

Ib. p. 213.—The marine reptiles associated under the term *Enaliosauria* were subsequently divided, as the number of discovered species increased, into the orders *Ichthyopterygia* and *Sauropterygia:* see Vol. III., pp. 1 and 41.

Ib. p. 405.—The genus *Cetiosaurus* was shown to belong to the order *Dinosauria:* see p. 577.

Ib. p. 426.—The suggestion at the foot of this page received the confirmation given in p. 627.

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PREFACE.

At the date of the last (posthumous) edition of Cuvier's 'Recherches sur les Ossemens Fossiles,'[1] descriptions and figures were given of a few fossil Crocodiles, to two Oolitic species of which Geoffroy St. Hilaire had given the generic names of *Teleosaurus* and *Steneosaurus*. To these follow descriptions of certain Tertiary Fossils of the order *Chelonia*, referable to the genera *Testudo*, *Emys*, *Trionyx*, and, by a Cretaceous form, to the genus *Chelone*.

To the order *Lacertilia* Cuvier refers the gigantic extinct Reptile from the Maestricht Chalk, since termed *Mosasaurus*, and the genus from secondary marls near Monheim to which he assigns the name *Geosaurus*, not intimating thereby that the species was exclusively terrestrial, but "par allusion à la terre mère des géans" (p. 184, t. x.).

Cuvier then gives a summary of Buckland's discovery and description of the remains from the Oxford Oolite, referred to the genus *Megalosaurus*, "qui paraît tenir des *Sauriens* et des *Crocodiles*" (p. 185); also of Mantell's discovery of fossils from the Weald of Sussex which, after Cuvier's opinion on the dental character, were referred to the genus *Iguanodon*. Cuvier then proceeds to the description of Collins's and Soemmering's fossils of a volant animal which was determined by Cuvier to be those of a Reptile, and for which he proposes the name *Pterodactylus*. At that date no evidences of this genus had been recognised in secondary or other formations of Britain. The descriptions and inferences occupying pp. 215, 261, of the concluding volume of the 'Ossemens Fossiles' are models of palæontographical work. Cuvier finally translates, with original remarks, the descriptions by Home and de la Beche of the *Ichthyosaurus*, and those by Conybeare of the *Plesiosaurus;* the letterpress figures being limited to a single species of each of these Liassic genera.

In conclusion, the immortal Founder of Palæontological Science, writes:—"J'avais aussi le projet de donner des chapitres sur les os d'oiseaux et de serpens; mais—j'ai dû renoncer à cette partie de mon plan" (tome dixième, p. 475).

[1] 8vo, 10 volumes, edited by M. Frédéric Cuvier, 1834—1836.

After referring to the localities in which the remains attributed to birds (as those by Buckland from the Oolitic Slate of Oxford) had been found, Cuvier proceeds:—"Les os de serpens sont encore plus rares, s'il est possible. Je n'en ai vu que des vertèbres des brèches osseuses de Cette, et une seule des terrains d'eau douce de l'Ile de Sheppey" (ib., p. 476).

My determination of the Fossil Remains collected by JOHN HUNTER and described in the 'Catalogues of the Hunterian Collections' then under my charge, together with the knowledge of other fossil remains of Reptilia with which holiday geological excursions and the transmissions by local collectors had made me acquainted, begat a conviction that the contributions of Buckland, De la Bèche, Conybeare, and Mantell, were but the forerunners of other, probably much more extensive, acquisitions of evidences of Reptilian modifications of vertebral structures from British strata. The application of a grant by the "British Association for the Advancement of Science," in aid of such research, enabled me to visit and personally explore the most promising localities of Reptilian Fossils, the results of which were communicated in two "Reports," published in the 'Transactions of the Association' for the years 1841 and 1842.

The foundation of the "Palæontographical Society," in which I co-operated with BOWERBANK, THOMAS BELL, and SEARLES WOOD, gave subsequent opportunities of putting on record the characters of species of British Fossil Reptiles, at that time new to science.

The contribution of such descriptions to the annual volumes was attended with the Society's permission to take, at my own cost, impressions of the plates, after their use by the Society, for the purpose of the present work.

Its issue in "Parts" exhausted the materials at my command in 1854, and I thought that the new Fossil Reptiles, of which I received indications, would occupy a concluding part of like size and number of plates with its forerunners. But the acquisitions of fragmentary fossils, suggestive of new species or genera of *Reptilia*, beguiled me into procrastinating hopes of reconstructions which, in some instances have been fulfilled. In the excitement of such quests after draconic forms time passes swiftly, and conviction becomes imperative that it must have a term. Moreover, a Record of what may have been discovered of a given group or class of Natural Objects, especially of Fossil Remains, with figures aiding recognition and comparison, becomes a help and stimulus to rapid and extensive additions. The attempt to grapple with these and make them usefully known has absorbed year by year such leisure as I could so devote after official duties. The result is summarised in the Indexes to Volumes I and III of the present work.

Another benefit flows from publication; the correction, viz. of errors into which the author may have fallen. His acceptance, for example, of Mantell's and Cuvier's determinations of parts of the Iguanodon as the "tympanic bone" and "clavicle" has been rectified; in regard to the first, by the accomplished Professor Seeley's recognition of it as part of a vertebra of another genus and species; and, in regard to the second, by Professor Leidy's reference of it to a part of the pelvis, as a pubic bone.

The more recent discovery, in a Belgian locality, of an almost entire skeleton of an Iguanodon confirms these rectifications, and almost completes the restoration of that truly remarkable gigantic extinct form of phytophagous Reptile.[1] And here I cannot but gratefully notice the truly valuable additions to our knowledge of Dinosaurian fossils made by the personal labours, enterprise, and science of Professor O. C. Marsh, of Yale College, New Haven, Connecticut, United States.

Such indications of the numbers of animal forms, which have existed during long epochs of our earth's past history, give an impression that the labours of an individual devoted to the fossil remains of a limited group can but leave a mere sketch of a fragment of the class—a sketch, however, which cannot fail to be filled in by the labours of successive generations of Palæontologists.

[1] These remains were discovered, in 1881, at Bernissart, and their matrix was determined by the accomplished Director of the Royal Museum of Natural History, Brussels, Prof. Edouard Dupont, to belong to the Wealden Series; the fossils are referred by Prof. P. G. Van Beneden to belong to the species *Iguanodon Mantelli*. ('Bulletin de l'Academie Royale des Sciences de Belgique,' 8vo, 1881, p. 600.)

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A HISTORY

OF

BRITISH FOSSIL REPTILES.

CHAPTER I.—Order *CHELONIA.*

TURTLES, TERRAPENES, AND TORTOISES.

§ 1. *Introductory Remarks on the Homology of the Carapace and Plastron.*

The majority of the Fossil Chelonians, defined or described in my 'Report on British Fossil Reptiles,'* belonged to the marine division of the order, and as the species of this family depart least from the ordinary reptilian type in the modification of the bones of the trunk, composing the characteristic thoracic-abdominal case of the order, I propose to commence with them the descriptions of the Fossil *Reptilia* which form the subject of the present Chapter.

In order to facilitate the comprehension of the descriptions and figures of the fossil Chelonians, a brief notice is premised of the composition and homologies of the carapace and plastron, or roof and floor, of that singular portable abode, with which the reptiles of the present order have been endowed in compensation for their inferior powers of locomotion or other modes of escape or defence.

In the marine species of the Chelonian order, of which the *Chelone mydas* may be regarded as the type, the ossification of the carapace and plastron is less complete, and the whole skeleton is lighter than in those species that live and move on dry land: but the head is proportionally larger—a character common to aquatic animals,—and being incapable of retraction within the carapace, ossification extends in the direction of the fascia, covering the temporal muscles, and forms a second bony covering of the cranial cavity: it is interesting to observe, however, that this accessory defence is not formed by the intercalation of any new bones, but is due to exogenous growth from the frontals (11), parietal (7), postfrontals (12), and mastoids (8, see Pls. 11, and 17*A*).

The bony carapace is composed externally of a series of median and symmetrical pieces (fig. 1, *ch*, *s*1—*s*11, *py*), and of two series of unsymmetrical pieces (*pl*1—8, *m*1—12) on each side. The median pieces have been regarded as lateral expansions of the summits of the upper vertebral (neural) spines,† the median lateral pieces as similar

* Reports of the British Association for the Advancement of Science, 1841, p. 160.

† Cuvier, Leçons d'Anatomie Comparée, tom. i (1799), p. 212.

developments of the vertebral ribs (pleurapophyses),* and the marginal pieces as the homologues of the sternal ribs (hæmapophyses).†

I must refer the reader to my Memoir, communicated to the Royal Society, Jan. 18, 1849, for the facts and arguments which have led me to regard these pieces, as dermal ossifications, homologous with those that support the nuchal and dorsal epidermal scutes in the crocodile. Most of the bony pieces of the carapace are, however, directly continuous, and connate,‡ with the obvious elements of the vertebræ, which have been supposed exclusively to form them by their unusual development; the median pieces have accordingly been called "vertebral plates," and the medio-lateral pieces "costal plates." I retain the latter name, although with the understanding and conviction that they are essentially or homologically distinct parts from the vertebral ribs or pleurapophyses with which they are connate and more or less blended. But, with regard to the term "vertebral" plate, since the ribs (*costæ*) are as essentially elements of the vertebræ as the spinous processes themselves, I have been in the habit, in my Lectures, of indicating the median series by the term "neural plates," which term has the further advantage of removing any ambiguity from the descriptions that might arise from their being mistaken for the superincumbent epidermal shields, which are likewise called "vertebral plates" in some English works.§ The term "marginal" is retained for the osseous plates forming the periphery of the carapace; but the median and symmetrical ones, which seem also to begin and end the "neural" series, are specified, the one by the term "nuchal plate," the other by that of "pygal plate." The "neural plates" are numbered as in the classical Monograph of Bojanus.‖

In the subjoined woodcut of the carapace of the loggerhead turtle (*Chelone caouanna*) (fig. 1), *ch* is the *nuchal plate;* *s*1 to *s*11 the *neural plates;* *pl*1 to *pl*8 the *costal plates;* and *m*1 to *m*12 the marginal plates. The carapace is impressed by the superimposed epidermal scutes or shields, which consist of a median series, called "*vertebral scutes*" *v*1 to *v*5;

* Ibid. p. 211. Rathké has recently supported this determination by arguments drawn from the mode of development of the carapace. See 'Annales des Sciences Naturelles,' Mars, 1846; and 'Ueber die Entwickelung der Schildkröten,' 4to, 1848, where he says, p. 105:—"Ausser den Rippen und den horizontal liegenden Tafeln, zu welchen sich die Dornfortsätze des zweiten und der sechs folgenden Rückenwirbel ausbilden, dienen bei den erwachsenen Schildkröten zur Zusammensetzung des Rückenschildes noch eine oder mehrere Knochenplatten," viz. the "marginal plates." I have shown how Rathké was deceived by over-estimating the character of connation, in my 'Observations on the Development of the Carapace and Plastron of the Chelonians,' which conduct to a different conclusion to that at which Cuvier and Rathké have arrived. (Philosoph. Transactions, 1849.)

† Geoffroy, Annales du Museum, tom. xiv (1809), p. 7.

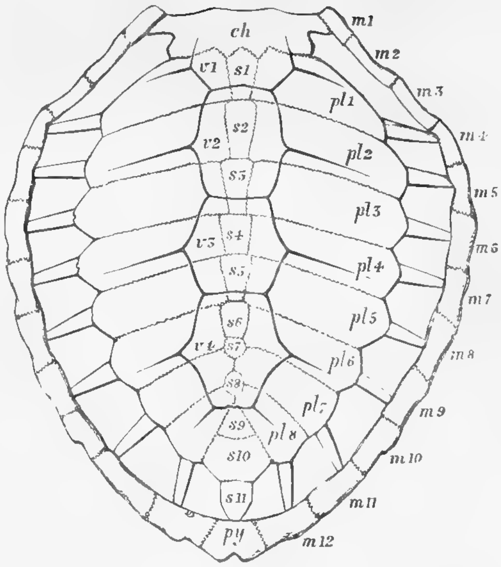
‡ This term is used in the definite sense explained in my work on the 'Archetype of the Vertebrate Skeleton' (8vo, V. Voorst, p. 49), as signifying those essentially different parts which are not physically distinct at any stage of development; and in contradistinction to the term "confluent," which applies to those united parts which were originally distinct.

§ See Griffiths's translation of Cuvier, vol. ix, Synopsis of Reptilia, p. 6—"fifth vertebral plates prominent."

‖ Anatome Testudinis Europææ, fol. 1821, tab. iii and iv.

and of a lateral series of "*costal scutes;*" there is also a peripheral series of "*marginal scutes*" corresponding with and impressing the marginal plates. The nuchal plate (*ch*) is remarkable for its breadth in all Chelonia, and usually sends down a ridge from the middle line of its under surface, which is attached by ligament to the summit of the neural arch of the first dorsal vertebra. The first true neural plate, *s*1, is much narrower, and is connate with the summit of the neural spine of the second dorsal vertebra; the succeeding vertebral neural plates, *s*2—*s*8, have the same relations with the succeeding neural spines, but the ninth, tenth, and eleventh, like the nuchal (*ch*) and pygal (*py*), plates are independent ossifications in the substance of the derm. The costal pieces of the carapace are supra-additions to eight pairs of pleurapophyses or vertebral ribs, those, viz. of the second to the ninth dorsal vertebræ inclusive. The slender or normal portions of the ribs project freely for some distance beyond the expanded and connate portions ("costal plates" of the carapace), along the under surface of which the rib may be traced, of its ordinary breadth, to the neck and head, which liberates itself from the costal plate to articulate to the interspace of the two contiguous vertebral bodies, (centrums), to the posterior of which such rib properly belongs.

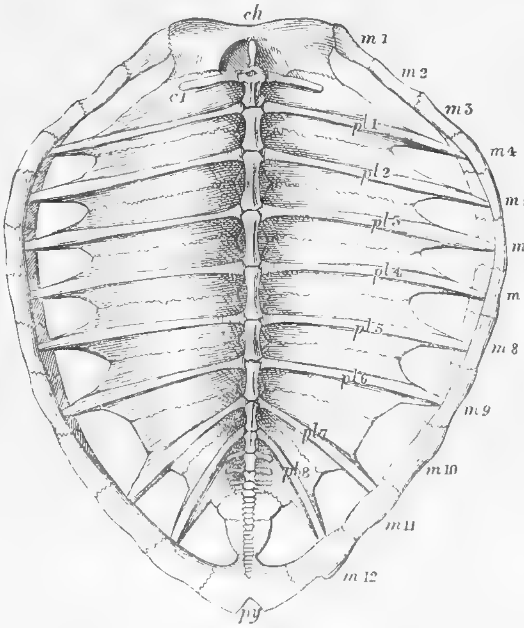
Fig. 1.



Carapace of the Loggerhead Turtle (*Chelone caouanna*)

The woodcut (fig. 2) illustrates this structure: *ch* shows the inner side of the nuchal plate; *c*1 is the first rib, articulated to the fore part of the body of the first dorsal vertebræ; *pl*1 is the first rib of the carapace (the second rib of the dorsal series), connate with the first costal plate; *pl*2 to *pl*8, are the succeeding ribs and costal plates of the carapace. The heads of the ribs articulate to the interspaces between their own vertebral body, and that of the preceding vertebra.

Fig. 2.



Inner view of carapace of the Loggerhead Turtle (*Chelone caouanna*).

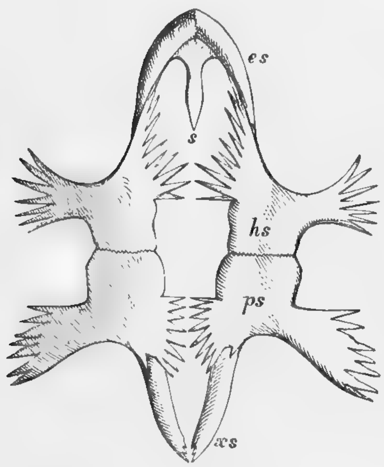
The tenth vertebra supports a short pair of ribs in *Chelone* and in *Emys*, but not in *Trionyx;* and this vertebra is commonly reckoned as a "lumbar" one. The eleventh and twelfth vertebræ have short and thick ribs, which abut against the iliac bones, and they are regarded as forming the sacrum. The remaining vertebræ belong to the tail, and are "caudal." The costal plates articulate with each other, and with the neural plates by fine dentated sutures. The free extremities of the ribs are implanted into sockets of those marginal plates which are opposite to them. The 1st, 2d, 3d, and 10th, are not so articulated in the loggerhead turtle. But all the marginal plates articulate with each other, and with the nuchal (*ch*) and pygal (*py*) plates by sutures.

The osseous basis of the plastron consists of nine pieces, one single and symmetrical, the rest in pairs.

The median piece, *s*, is the *entosternal;* the anterior pair, *es*, is the *episternal;* the second pair, *hs*, the *hyosternal;* the third pair, *ps*, the *hyposternal;* and the posterior pair, *xs*, the *xiphisternal.*

With regard to the nature or homologies of these bones, three views have been taken. The one generally adopted, on the authority of Cuvier, Bojanus, and Geoffroy St. Hilaire, is, that the nine bones of the plastron are subdivisions of a vastly expanded sternum, or breast-bone; the second view is, that these subdivisions of the sternum are enlarged by combination with ossifications of the integument;* and the third view, in which Rathké stands alone, is, that they are exclusively dermal bones, and have no homologues in the endoskeleton of other vertebrata.†

Fig. 3.



Bones of the plastron of the Loggerhead Turtle (*Chelone caouanna*).

Since this opinion is given as the result of that celebrated embryologist's observations on the development of the Chelonian reptiles, I have tested it by a series of similar researches on the embryos and young of the *Chelone mydas* and *Testudo indica*, and have been led by them to conclusions distinct from any of the three theories above cited.

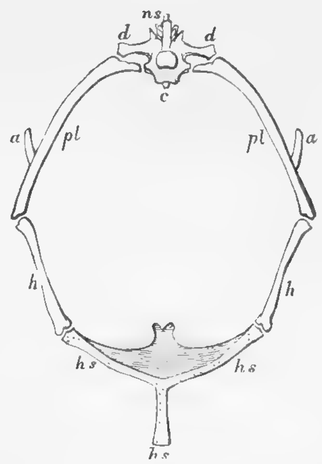
The sternum, like the carapace, is, without doubt, a compound of connate endoskeletal and exoskeletal pieces; but the endoskeletal parts are not exclusively the homologues of the sternum. For the details of the observations, and the special arguments on which these conclusions are founded, I must refer to the description of Pl. 1, and to my paper in the 'Transactions of the Royal Society,' 1849; the homologies of the endoskeletal parts of the plastron will require a brief illustration here from comparative anatomy.

* Peters, Observationes ad Anatomiam Cheloniorum, 1838.

† Ueber die Entwickelung der Schildkröten, 4to, 1848, p. 122.

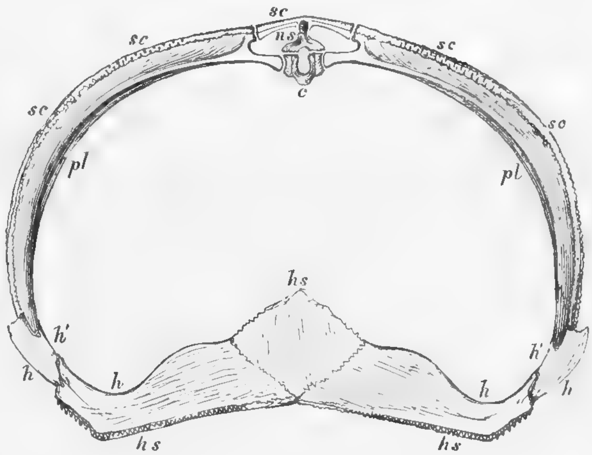
Geoffroy St. Hilaire, whose views are generally adopted, was guided in his determination of the parts of the plastron by the analogy of the skeleton of the bird: which analogy may be illustrated by the subjoined diagrams of corresponding segments of the thorax of a bird (fig. 4) and of a tortoise (fig. 5). In both figures *c* is the centrum or vertebral body; *ns* the neural arch and spine; compressed in the bird, depressed and laterally expanded, according to Geoffroy, in the tortoise; *pl* the pleurapophysis, or vertebral rib, expanded in the tortoise, and with its broad tubercle articulating with the expanded spine; *h*, *h′* in fig. 5, answers to *h* in fig. 4, and is the hæmapophysis (sternal rib, or ossified cartilage of the rib); *h*, *hs* in fig. 5, is *hs* in fig. 4, i. e. exclusively a sternum, with the entosternal piece, *hs′*, developed horizontally in the tortoise, and vertically in the bird. The *primá facie* simplicity of this view has imposed upon most comparative anatomists: and yet there are other vertebrate animals more nearly allied to the *Chelonia* than birds, and with which, therefore, comparison should have been instituted before general consent was yielded to the Geoffroyan hypothesis. If, e. g. we take the segment of a crocodile's skeleton (fig. 6) corresponding with that of the tortoise (fig. 5), the comparison will yield the following interpretation: in both figures *c* is the centrum: *ns* the neural arch and spine, with *d* the diapophysis; *sc* a median dermal bony plate (connate with *ns* in the tortoise); *pl* the pleurapophysis; *sc sc* lateral dermal bony plates (connate with *pl* in the tortoise); *h*, *h′* in fig. 5, answers to *h′* in fig. 6, an intercalated, semi-ossified piece between *pl* and *h* in the crocodile; *h*, *hs* in fig. 5, answers to *h*, the hæmapophysis in the crocodile; and *hs* in fig. 5, exclusively represents *hs*, the sternum in the crocodile.

Fig. 4.



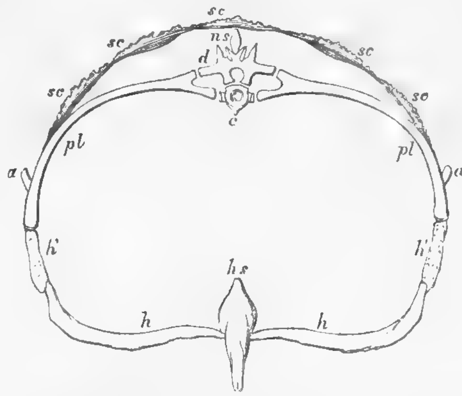
Thoracic segment of the skeleton of a Bird.

Fig. 5.



Thoracic segment of the skeleton of a Tortoise.

Fig. 6.



Thoracic segment of the skeleton of a Crocodile

Such a comparison, in my opinion, guides us to a truer view of the homologies of the thoracic-abdominal bony case of the Chelonians, especially with regard to the lateral or parial pieces of the plastron, than the comparison exclusively relied on by Geoffroy St. Hilaire. The *Plesiosaurus*, by its long and flexible neck, small head, expanded coracoid and pubis, and flattened bones of the paddles, comes much nearer to the turtle than the crocodile does; and its abdominal ribs, or hæmapophyses, are more developed than in the crocodiles; a comparison of the ventral surface of the skeleton, such as that figured by Dr. Buckland, in his 'Bridgewater Treatise,' vol. ii, pl. 18, fig. 3, will show how clearly those abdominal ribs would correspond with the hyosternals and hyposternals of the turtle, if they had coalesced together at their middle parts, leaving their outer and inner extremities free.

With regard to the marginal pieces *m*1—*m*12, figs. 1 and 2, although the comparisons illustrated by figs. 4, 5, 6, show that they answer rather to the intercalated piece *h'* in the crocodile than to the entire sternal rib *h* in the bird; yet the phenomena of their development demonstrate that they are exclusively bones of the dermal skeleton, retaining their freedom from anchylosis with the endoskeletal elements, like the nuchal, pygal, and last three neural plates (*ch*, *py*, *s*9, *s*10, and *s*11, fig. 1). This insight into their true nature teaches why they do not correspond in number with the vertebral ribs or pleurapophyses (*pl*1—*pl*8, fig. 2). In the loggerhead turtle, for example, the first three and the tenth (*m*1, *m*2, *m*3, and *m*10) have no corresponding pleurapophyses articulating with them; and if even *c*1 be supposed to correspond to *m*3, there are no rudiments of ribs answering to *m*1 and *m*2. The marginal plates are not constant in number; the *Chelone mydas* has two less than the *Chelone caouanna* has. Some species of *Trionyx* (*Cryptopus*, Dum. and Bibron) have a greater number, but of smaller and less regular size, confined to the posterior part of the limb of the carapace; in other species of *Trionyx* (*Gymnopus*, Dum. and Bibron), and in *Sphargis*, the marginal part of the carapace retains its embryonic condition in all *Chelonia*, as a stratum of cartilaginous cells in the substance of the derm, forming the thickened, flexible border of the carapace.

The rudiments of the hyosternals and hyposternals (Pl. 1, fig. 2*a*) have originally the form of sternal or abdominal ribs; extend transversely, and rise at their outer extremities to join those of the first and sixth pair of vertebral ribs, completing the hæmal, or inferior vertebral arch (ib., fig. 14), without the interposition of any of the marginal pieces, which are merely applied to the outer sides of the hæmapophysis or sternal ribs. The expansion of the parts of the plastron, especially in the fresh-water and land tortoises, is due chiefly to the ossification of a layer of cartilage-cells in the substance of the derm, which ossified plates are connate with the more internal elements of the plastron, representing the sternum and sternal ribs. In the following descriptions of the fossil *Chelonia*, the terms 'entosternal, episternal, hyosternal, hyposternal,' and 'xiphisternal,' will be used as absolute designations of the combined endoskeletal and exoskeletal bones of the plastron, without implying assent to the hypothesis that first suggested those names to Geoffroy St. Hilaire.

The scapular and pelvic arches, and the bones of the extremities of the *Chelonia*, are described and figured in the 'Ossemens Fossiles' of Cuvier;* where, also, the figures of the modifications of the carapace and plastron, in the fresh-water and land tortoises, will suffice for the purpose of ulterior comparisons with the fossils described in the present work, if they be understood according to the homologies above discussed, and which are illustrated by the figures 1 and 2 of the carapace, and fig. 3 of the plastron of the *Chelone caouanna*.

§ 2. *Family* MARINA.
Genus CHELONE.

With regard to the more immediate subjects of the present chapter, it must be admitted that the important generalizations of Cuvier and Dr. Buckland† have been confirmed, but not materially extended, by subsequent observations on the remains of reptiles of the Chelonian order. Cuvier, after admitting that his results in regard to the tortoises were not so precise as those relating to the crocodiles, sums up his chapter on the fossil *Chelonia* in the following words: "Toutefois nous avons pu nous assurer que les tortues sont aussi anciennes dans le monde que les crocodiles; qu'elles les accompagnent généralement, et que le plus grand nombre de leurs débris appartenant à des sous-genres dont les espèces sont propres aux eaux douces ou à la terre ferme, elles confirment les conjectures que les os de crocodiles avoient fait naître sur l'existence d'iles ou de continens nourissant des reptiles, avant qu'il y ait eu des quadrupèdes vivipares, ou du moins avant qu'ils aient été assez nombreux pour laisser une quantité de débris comparable à ceux des reptiles."‡

Dr. Buckland also states, in general but precise terms, that "the Chelonian reptiles came into existence nearly at the same time with the order of *Saurians*, and have continued coextensively with them through the secondary and tertiary formations unto the present time. Their fossil remains present also the same threefold divisions that exist among modern *Chelonia* into groups, respectively adapted to live on land, in fresh water, or the sea."§

The remains of sea turtles (*Chelone*) have been recognised in the Muschelkalk, the Wealden, the lower cretaceous formation at Glaris, and the upper chalk-beds at Maestricht. Figures of Chelonites, as that in the Frontispiece to Woodward's 'Synoptical Table of British Organic Remains,' and in König's 'Icones Sectiles' (pl. xviii, fig. 232, *a* and *b*), have been published; but no true marine Chelonian, from Eocene strata, had been scientifically determined prior to the communication of my Paper on that subject to the Geological Society of London.‖ All the Chelonites from

* Tom. v, pt. 2, pl. xii and xiii.

† Bridgewater Treatise (1836), p. 256.

‡ Ossemens Fossiles, 4to, tom. v, pt. ii, p. 249.

§ Bridgewater Treatise, p. 256.

‖ Proceedings of the Geological Society of London, vol. iii, pt. ii, p. 570, December 1, 1841.

Sheppey, described and figured in the last edition of Cuvier's 'Ossemens Fossiles,' for example, are referred to the fresh-water genus *Emys;* and the statement in the earlier edition of the 'Ossemens Fossiles,' that the greater part of the remains of Chelonian reptiles belong to the fresh-water or terrestrial genera, is repeated.

The aim of the Memoir, communicated to the Geological Society in December, 1841, was to show that the conclusion deduced by Cuvier, from an imperfect carapace from Sheppey, which might probably have belonged to a species of *Emys,* had been unduly extended to other Chelonites, which undoubtedly belonged to the marine genus *Chelone;* and that this genus was represented, in the Eocene strata, by at least six species; the remains of five of which were from the London Clay at Sheppey, and those of a sixth were tolerably abundant in the cliffs near Harwich.

In the carapace of the fossil Chelonian from Sheppey, communicated by Mr. Crowe, of Faversham, to Cuvier, and figured in the 'Ossemens Fossiles' (tom. v, part 2, pl. xv, fig. 12), the author of that great work conceived that all the characters of the genus *Emys* were perfectly recognisable.

He points out the proportions of the neural plates, which are as long as they are large; and in the figure they are represented of nearly a quadrate form, and not rhomboidal.

The fifth neural plate in the fragment figured (probably the eighth) is separated from the sixth (ninth) by a point, which is made by the mesial ends of the fifth (probably the seventh) pair of costal plates; a structure which Cuvier says slightly recalls what he had observed in the Jura *Emys* of Soleure.*

But Cuvier admits that the neural plates (*plaques vertébrales*) are narrower than those of existing *Emydes;* and that the equal breadth of the ribs is a character common to the *Chelones* with the *Emydes.*

Now, in reference to the carapace figured by Cuvier, it is to be observed, that the margins are wanting; and that the broad conjoined portions of the costal plates are not longer than they might have been, had the fossil belonged to a turtle (*Chelone*); and, consequently, that there is no proof that they were united together by suture throughout their whole extent, as in the *Emydes;* but that they might have terminated in narrow tooth-like processes, as in the *Chelones.*

The narrowness of the neural plates is a character which, with their smoothness, undoubtedly approximates the fossil to the *Chelones;* and, without intending to affirm that the fossil in question does not belong to the family *Emydidæ,* which unquestionably existed at the time of the deposition of the Sheppey clay, its determination appears to me to be much less decisive than might be inferred from the remarks in the 'Ossemens Fossiles.'

* Tom. cit., p. 234. This structure is not, however, peculiar to the genus *Emys;* in the carapace of the *Chelone caouanna,* in the Museum of the Royal College of Surgeons, the seventh neural plate is separated from the eighth by the junction of the expanded extremity of the seventh rib on one side with that of the opposite rib, and the eighth neural plate from the ninth by the same modification of the eighth pair of ribs. A similar modification may also be seen in the carapace of the *Trionyx Henrici,* Pl. 6.

Mr. Parkinson describes the plastron of a Sheppey Chelonite,* in which the hyosternal and hyposternal pieces are not united, but leave a vacancy in the middle, which he conjectured may have been filled up by membrane. This specimen must have belonged to a specimen at least four inches in length, exclusive of the head and neck. But Cuvier supposes that it may, nevertheless, have belonged to an *Emys;* and that the vacancy of the bony sternum merely indicated the nonage of the individual.†

The grounds on which Cuvier refers to the genus *Emys*, the imperfect and dislocated carapace and plastron of M. Bourdet's Sheppey Chelonite,‡ are not detailed; but it is evident that the hyposternals in that specimen are in contact at the posterior moiety of their median margins only; and that the margins recede anteriorly, leaving a median interspace; which, as the plastron is nearly a foot in length, can hardly be attributed to the immature state of the individual. And if, as Cuvier supposes, this specimen belongs to the same species as those in the collections of Messrs. Crowe and Parkinson, the same objection to their belonging to a fresh-water tortoise holds good, as to the one figured by M. Bourdet.

The question of the reference of these Eocene fossils to the fresh- or sea-water families of the Chelonian order, seems to me to admit of the safest determination by examining the crania of the Sheppey Chelonites; since the differences in the extent to which the temporal fossæ are protected by bone, and in the proportions in which the bones enter into the formation of that covering, are strongly marked in the genera *Emys* and *Chelone.*

But here Cuvier appears to have been unusually biassed in favour of the Emydian nature of the Sheppey fossils; for in reference to the cranium, figured by Mr. Parkinson, the affinities of which to the turtle's skull will be presently pointed out, Cuvier observes: "elle est probablement aussi d'une Emyde, bien qu'elle participe des caractères de Tortues de Mer, par la manière dont le parietal recouvre sa tempe; mais nous avons vu que *l'Emys expansa* diffère très peu de Tortues de Mer à cet égard, et la partie antérieure de la tête fossile ressemble d'avantage à celle d'une Emyde qu' à celle d'une Chelonée, surtout par le peu de largeur de l'intervalle des yeux."§

Now the most striking difference between the temporal bony vault of the *Emys expansa* and that of any known species of *Chelone,* is seen in the diminutive size of the post-frontals in this exceptional case among the *Emydes,* as contrasted with their large size and actual extension over the temporal fossæ in the *Chelones:*—and this difference is accompanied by a proportional diminution in the breadth of the parietals in the true marine turtles.

* Organic Remains, vol. iii, p. 268, pl. xviii, fig. 2.

† Ossemens Fossiles, tom. v, pt. ii, p. 235.

‡ Tom. cit., pl. xv, figs. 14-15.

§ Tom. cit., p. 235.

But the figure in Parkinson's work gives clearly the latter character; whence also we may infer that it agreed more with the *Chelones* also in the size of the postfrontals; although the anatomy of the skull is too obscurely delineated to demonstrate this fact.

The following important affinities are, however, unquestionably indicated in Parkinson's figure:—*first*, the large size of the orbits, which are nearly six times greater than those of the *Emys expansa; secondly*, their more posterior and lateral position; and *thirdly*, the greater breadth of the interorbital space: in all which characters the Sheppey fossil closely resembles the true *Chelones*, and differs from the only known species of *Emys* (*Podocnemys*) *expansa*, in which the temporal openings are protected by a bony roof.

That fresh-water tortoises have left their bony cuirasses in the Sheppey clay, will be subsequently shown; but the evidence of the genus *Emys*, adduced by Cuvier, is incompetent to prove their existence; and, it may be affirmed, that of the fossils cited by the founder of Palæontology, some, with great probability, and others with certainty, are referable to the marine genus, *Chelone*.

Without further discussing the question as regards these evidences, I shall proceed to describe the specimens from Sheppey which I have myself had the opportunity of examining; and shall commence with those which belong undoubtedly to the marine family.

CHELONE BREVICEPS. *Owen.* Plates 16, 17, 17*A*.

Proceedings of the Geological Society, December 1, 1841; Report on British Fossil Reptiles, Trans. British Association, 1841, p. 178.

Syn. EMYS PARKINSONII. *J. E. Gray.*
— DE SHEPPEY. *H. v. Meyer* (?).
CHELONE ANTIQUA. *Kœnig* (?).

The first of the Chelonites, which led me to the recognition of this species, was a nearly perfect cranium from Sheppey (Pl. 17*A*, figs. 1—4), wanting only the occipital spine, and presenting a strong and uninterrupted roof, extended posteriorly from the parietal spine on each side (figs. 1 and 4, 7), over the temporal openings to the mastoids (ib. 8); and formed anteriorly by a great development of the posterior frontals (figs. 1 and 2, 12).

This unequivocal testimony of the marine genus of the fossil, is accompanied by similar evidence afforded by the large size and lateral aspect of the orbits (fig. 1, *or*), the posterior boundary of which extends beyond the anterior margin of the parietals; and by the absence of the deep emargination which separates the superior maxillary (ib, 21) and malar (26) from the squamosal (27) and the tympanic bone (28) in the fresh-water tortoises, and especially in the *Podocnemys expansa*.

In general form, the skull of the present species of Sheppey turtle resembles that of the *Chelone mydas*, BRONGN.: but it is relatively broader; the prefrontals (figs 1 and

2, 14) are less sloping, and the anterior part of the head is more vertically truncate. The orbits are relatively larger, and extend nearer to the tympanic cavity. The frontals (ib. 11) enter into the formation of the orbits in rather a larger proportion than in *Chelone mydas*. In the *Chelone caouanna** they are wholly excluded from the orbits.

The trefoil shape of the occipital tubercle is well marked (fig. 4); the depression in the basioccipital, bounded by the angular pterygoid ridges, is as deep as in most true turtles (fig. 3, 1); the lateral borders of the expanded parietals are united by a straight suture along a great proportion of their extent to the large postfrontals.

These proportions are reversed in the *Podocnemys expansa*, in which the similarly expanded plate of the parietals is chiefly united laterally with the squamosal and tympanic bones. In other fresh-water tortoises the parietal plate in question does not exist.

The same evidence of the affinity of the Sheppey Chelonite in question to the marine turtles, is afforded by the base of the skull (fig. 3); the basioccipital (1) is deeply excavated; the processes of the pterygoids (24), which extend to the tympanic pedicles, are hollowed out lengthwise: the palatal processes of the maxillary and palatine bones are continued backwards to the extent which characterises the existing *Chelones;* and the posterior or internal opening of the nasal passages, is, in a proportional degree, carried further back in the mouth. The lower opening of the zygomatic spaces is wider in the present Sheppey Chelonite, than in *Podocnemys expansa.*

The external surface of the cranial bones in the fossil is roughened by small irregular ridges, depressions, and vascular foramina, which give it a wrinkled or shagreen-like character.

The following are dimensions of the specimen described:

	Inches.	Lines.
Length of cranium from the occipital condyle	2	9
Breadth of cranium across the malars (26)	2	7
Antero-posterior diameter of orbit	1	0

The lower jaw, which is preserved in the present fossil, likewise exhibits two characters of the marine turtles; the dentary piece (fig. 3, 32), *e. g.* forms a larger proportion of the lower jaw than in the land or fresh-water tortoises. The joint of the rami is completely obliterated at the symphysis, which is not longer or larger than in *Chelone mydas.*

The species represented by this fossil, which is preserved in the British Museum, and by a very similar one in the Hunterian Collection (Pl. 17, figs. 1—5), is selected for the first of the Eocene Chelonians to be described in the present Work, because it is one of the few with which the characters of the carapace and plastron can with certainty be associated with those of the cranium.

In the rich collection of Sheppey fossils, belonging to J. S. Bowerbank, Esq. F.R.S.

* Ossem. Fossiles, tom. v, pt. ii, pl. xi, fig. 2.

there is a beautiful Chelonite (Pl. 16, figs. 1, 2) including the carapace, plastron, and the cranium, which is bent down upon the fore part of the plastron; and which, though mutilated, displays sufficient characters to establish its specific identity with the skull of the *Chelone breviceps* just described. Both the carapace and plastron present the same finely rugous surface externally as the cranium; in which character we may perceive a slight indication of affinity with the genus *Trionyx.*

The carapace (Pl. 16, fig. 1) is long, narrow, ovate, widest at its anterior half, and tapering towards a point posteriorly; it is not regularly convex, but slopes away, like the roof of a house, from the median line, resembling, in this respect, and its general depression, the carapace of the turtle *Chelone mydas.* There are preserved the nuchal plate (fig. 1, *ch**) with ten of the neural plates (*n*1—*n*10*), only the eleventh and pygal plates being wanting. The eight pairs of costal plates (*pl*1—*pl*8) are also present, with sufficient of the narrower tooth-like extremities of the six anterior pairs of ribs, to determine the marine character of the fossil, which is indicated by its general form.†

The nuchal plate (fig. 6, *ch*) is of a transversely oblong form, with the anterior margin gently concave. Its antero-posterior diameter, or length, is ten lines; its transverse diameter, or breadth, is two inches. The lateral margins are bounded by two lines meeting at a slight angle; to the anterior one, the first of the marginal plates, *m*1, is attached; the posterior line bounds part of the vacant interspace between the first costal plate (*pl*1), and the anterior marginal plate. The presence of this plate would prove for the genus *Chelone* as against *Trionyx*, were the characters of the cranium, the impressions of the vertebral scutes, and the sternum wanting. The nuchal plate in the *Emydes* is hexagonal, and nearly as long as it is broad.

The Chelonite from the tertiary beds near Brussels, figured by Cuvier,‡ has the nuchal plate of nearly the same form as the present specimen from Sheppey.

The neural plates in the *Chelone breviceps* are as narrow as in the *Chelones* generally; and as in the Brussels Chelonite above cited.

The first neural plate (*s*1, fig. 1) is four-sided; the rest, to the eighth (*s*8), are hexagons of a more regular figure than in the existing *Chelones,* and are articulated to more equal shares of the contiguous alternate costal plates (*pl*1—*pl*8).*

The first costal plate (*pl*1) is directed more outwards, does not incline backwards, as in recent *Chelones,* and its anterior angle is less truncated than in them. (See fig. 1, p. 3.)

The length of the second costal plate (*pl*2) is one inch, nine lines; more than half of the narrow terminal extremity of the connate rib is preserved; the proportions of

* These letters refer to the parts in the typical carapace fig. 1, p. 3, by reference to which the corresponding parts in the fossil will be readily understood.

† In an *Emys* with a carapace seven inches in length, the corresponding extremities of the ribs would have been united together by the laterally-extended ossification.

‡ Ossemens Fossiles, tom. v, pt. 2, pl. xv, fig. 16.

the remaining costal plates correspond with those of the *Chelone mydas,* and *Chel. caouanna.*

The last pair of costal plates (*pl*8) articulates with the eighth, ninth, and tenth neural plates, but does not overlap or supersede any of them.

Not any of the costal plates articulate with those of the opposite side, so as to interrupt the series of vertebral plates, as in the carapace of the *Chelone caouanna* (fig. 1, p. 3), as in Mr. Crowe's Sheppey Chelonite, figured by Cuvier (tom. cit. pl. xv, fig. 12); and as is shown in the view of the concave surface of the Brussels species (tom. cit. pl. xv, fig. 16).

The ninth neural plate (fig. 1, *s*9) is the narrowest, as in the *Chelones,* and as in the Brussels Chelonite, figured by Cuvier, in loc. cit. pl. xiii, fig. 8, instead of being suddenly expanded, as in most *Emydes.*

The tenth neural plate (*s*10) expands to a breadth equal with its length; the eleventh and pygal plates, as already observed, are wanting in the fossil.

The vertebral or median ends of the costal plates present a modification of form, corresponding with that of the interspaces of the neural plates to which they are articulated. Only the first pair (*pl*1) present that form which characterises all but the last pair in the existing *Chelones,* and in the Brussels Chelonite; viz., a straight line with the posterior angle cut off; the rest being terminated by two nearly equal oblique lines, meeting at an open angle, as shown in Pl. 16, fig. 1, *pl*2—*pl*7.

This character would serve to distinguish the *Chelone breviceps,* if only a portion of the carapace, including the vertebral extremity of a rib, were preserved. The free extremities of the ribs are thicker in proportion to the costal plates, than in the *Chelone caouanna,* or the *Chel. mydas;* and more resemble, in this respect, those of the *Chel. imbricata,* the species characterised by the size and beauty of the horny scutes, commonly called " tortoise-shell."

More or less complete impressions of the five horny vertebral scutes (*v*1—*v*5), and of four costal scutes on each side of the vertebral ones, show the forms and proportions of these characteristic parts, and especially of the median series, notwithstanding they were among the soluble and perishable elements of this ancient turtle of the Thames.

The hexagonal vertebral scutes are characterised by the near equality of their sides, and the angle of about 100°, at which the two outer sides meet.

The anterior border of the first vertebral scute, v^1, has crossed and impressed the nuchal plate, *ch,* near its anterior border; this scute has covered the rest of the nuchal plate, and more than half of the first neural plate. The second vertebral scute, v^2, includes the rest of the first neural plate, the whole of the second, and almost the whole of the third neural plate. The third vertebral scute, v^3, includes the hind border of the third neural plate, with the whole of the fourth and fifth neural plates. The fourth vertebral scute includes the sixth and seventh, and very nearly the whole of the eighth neural plates, and the outer angles of this scute terminate over the suture between the sixth and seventh costal plates.

The plastron of the *Chelone breviceps* (Pl. 16, fig. 2), although more ossified than in existing *Chelones*, yet presents all the essential characters of that genus. There is a central vacuity left between the hyosternals (*hs*)* and hyposternals (*ps*); but these bones differ from those of the young *Emys* in the long pointed processes which radiate from the two anterior angles of the hyosternals (*hs*), and the two posterior angles of the hyposternals (*ps*).*

The xiphisternals (*xs*) have the slender elongated form, and oblique union by reciprocal gomphosis with the hyposternals (*hs*), which is characteristic of the genus *Chelone*. The posterior extremity of the right episternal (*es*) presents the equally characteristic, slender pointed form.

With these proofs of the modification of the plastron of the present fossil according to the peculiar type of the marine *Chelones*, there is evidence, however, that it differs from the known existing species in the more extensive ossification of the component pieces; thus the pointed rays of bone extend from a greater proportion of the margins of the hyosternals and hyposternals; and the intervening margins do not present the straight line at right angles to the radiated processes.

In the *Chelone mydas*, and *Chel. caouanna* (fig. 3, p. 4), for example, one half of the external margin of the hyosternal and hyposternal, where they are contiguous, are straight, and intervene between the radiated processes, which are developed from the remaining halves, while in the *Chelone breviceps*, about a sixth part only of the corresponding external margins are similarly free, and there form the bottom, not of an angular, but a semicircular interspace.

The radiated processes from the inner margins of the hyosternals and hyposternals, are characterised in the *Chelone breviceps* by similar modifications, but their origin is rather less extensive; they terminate in eight or nine rays, shorter, and with intervening angles more equal than in existing *Chelones*. The xiphisternal piece, *xs*, receives in a notch the outermost ray or spine of the inner radiated process of the hyposternal, as in the *Chelones*, and is not joined by a transverse suture, as in the *Emydes*, whether young or old.

Subjoined are dimensions of the plastron of Mr. Bowerbank's fossil:

	Inches.	Lines.
Shortest longitudinal diameter of hyosternal and hyposternal pieces	2	5
Transverse diameter of ditto	1	7
Total length of plastron	6	0

The bones of the scapular arch, especially the coracoid, Cuvier has shown to afford distinctive characters of the natural families of the *Chelonia*; but the Eocene Chelonites described by Cuvier, did not yield him this opportunity of thus testing their affinities. In the *Chelone breviceps* here described, the left coracoid (shown in fig. 2) is preserved in nearly its natural position; it is long, slender, symmetrical; cylindrical near its humeral

* These letters refer to the parts in the typical plastron, fig. 3, p. 4, by reference to which the homologous parts in the fossil will be readily understood.

extremity; flattened, and gradually expanded from its humeral third, to its sternal end, which is relatively somewhat broader than in the *Chelone mydas* and *Chelone caouanna*.

	Inch.	Lines.
Its length is	1	6
Breadth of sternal end . . .	0	7

The characters thus afforded by the cranium, carapace, plastron, and by one of the bones of the anterior extremity, prove the present Sheppey fossil to belong to a true sea turtle; and at the same time most clearly establish its distinction from the known existing species of *Chelone*.

On account of the shortness of the skull, especially of the facial part and of that which intervenes between the orbit and ear, compared with the breadth of the skull across the mastoids, I have proposed to name this extinct species, *Chelone breviceps*.*

By the characteristic shape of the median extremities of the costal plates of the carapace, I have been able to determine some fragmentary Chelonites which have afforded better ideas of the size of the species represented by Mr. Bowerbank's more complete but immature specimen of *Chelone breviceps*.

A portion of the carapace of the *Chelone breviceps*, including the fourth, fifth, sixth, and part of the third and seventh neural plates, with a considerable proportion of the third, fourth, fifth, and sixth costal plates, is preserved in the museum of Mr. Robertson, of Chatham. The characters of the rugous surface of these bones, and of the equal-sided angles by which the costal plates articulate with the neural plates, do both, and especially the latter, point out the species to which the present fragment belongs. It has formed part of an individual double the size of the specimen above described, and figured from Mr. Bowerbank's collection, and therefore it had a carapace sixteen inches in length.

Although the costal plates have been continued further along the ribs than in the younger example, the more complete state of the sixth rib, in Mr. Robertson's specimen, shows that they retained their longitudinally-striated, tooth-like extremities, which, in the sixth rib, is two thirds of an inch in length; the length of the expanded part being four inches, and its breadth one inch nine lines. The internally prominent part of the rib is much less developed than in *Chelone planimentum*, and *Chelone crassicostata*, afterwards to be described. The right hyosternals and hyposternals are present, and they likewise preserve the character of the *Chel. breviceps* in their rugous surface and minor breadth, as compared with those parts in the *Chelone longiceps*, the extinct species next to be described.

Besides the specimens above described, on which the present extinct species of turtle

* Proceedings of Geological Society, December 1, 1841, p. 570. Report on British Fossil Reptiles, Trans. Brit. Association, 1841, p. 178.

has been established, remains of the *Chelone breviceps* are preserved in the Hunterian Museum, and in that of my esteemed friend Professor Bell, S.R.S.

I know no other locality of the species than that of Sheppey, in Kent.

CHELONE LONGICEPS. *Owen.* Pl. 12 and 13.

Proceedings of Geological Society of London, December 1, 1841, p. 572. Report on British Fossil Reptilia, Trans. British Association, 1841, p. 177.

The second species of *Chelone,* from the Eocene clay at Sheppey, which I originally recognised and defined by the fossil skull (Pl. 12) differs more from those of existing *Chelones* by the regular tapering of that part into a prolonged pointed muzzle, than does the *Chelone breviceps* by its short and anteriorly-truncated cranium.

The surface of the cranial bones is smoother than in the *Chel. breviceps;* whilst their proportions and relations prove the marine character of the present fossil as strongly as in that species.

The orbits (Pl. 12, figs. 1 and 2, *o,*) are large; the temporal fossæ (ib. fig. 3) are covered principally by the posterior frontals (fig. 2, 12); and the osseous shield completed by the parietals (7), and mastoids (8), overhangs the tympanic (28), ex-occipital (2), and paroccipital (4) bones. The compressed spine (3)* of the occiput is the only part that projects further backwards.

The palatal and nasal regions of the skull afford further evidence of the affinities of the present Sheppey Chelonite to the true turtles. The bony palate (fig. 3) presents, in an exaggerated degree, the great extent from the intermaxillary bones to the posterior nasal aperture which characterises the genus *Chelone;* and it is not perforated, as in the soft turtles (*Trionyx*), by an anterior palatal foramen.

The extent of the bony palate is relatively greater than in the *Chelone mydas,* and the trenchant alveolar ridge is less deep; the groove for the reception of that of the lower jaw is shallower than in the *Chelone mydas,* or the extinct *Chel. breviceps,* arising from the absence of the internal alveolar ridge, in which respect the *Chel. longiceps* resembles the *Chel. caretta.*

The *Chelone longiceps* is distinguished from all known existing *Chelones* by the proximity of the palatal vomer (13, fig. 3), to the basisphenoid (5), and by the depth of the groove of the pterygoid bones (24),* and in both these characters in a still greater degree from the Trionyxes; to which, however, it approaches in the elongated and pointed form of the muzzle, and the trenchant character of the alveolar margin of the jaws.

The following are dimensions of the skull described:

	Inches.	Lines.
Length of the skull	4	0
Breadth of ditto across the zygomata	2	6
Antero-posterior diameter of orbit	1	2

* The smaller figures are placed on the parts in Pls. 11 and 17*A*, by comparison with which the corresponding bones of the present skull will be readily discerned.

In a second example of the skull of *Chelone longiceps*, two of the middle neural plates, and the corresponding costal plates of the right side, portions of vertebræ, with the right xiphisternal piece, humerus and femur, are cemented together, and to the cranium by the petrified clay.

The neural plates in this specimen are flat and smooth; the entire one measures one inch two lines in length, and nine lines across its broad anterior part:—this receives the convex posterior extremity of the preceding plate in a corresponding notch. A small proportion, about one sixth, of the anterior part of the external margin, joins the second costal plate; the remaining five sixths of the outer margin forms the suture for the vertebral end of the third costal plate.

In this respect, the *Chel. longiceps* resembles the existing *Chelones;* and differs, as well as in the smooth and flattened surface of the vertebral plates, from the *Chelone breviceps*. The length of the third costal plate, in the fragmentary example here described, is three inches; the impression of the commencement of the narrow portion, formed by the extremity of the coalesced rib, is preserved.

The marginal indentations of the vertebral scutes are not half a line in breadth.

The transverse impression between the first and second vertebral scute crosses the first neural plate, nine lines from its posterior extremity; the second neural plate is free, as in other *Chelones*, from any impression, being wholly covered by the second vertebral scute.

The expanded ribs are convex at the under part, slightly concave at the upper part in the direction of the axis of the shell; they slope very gently from the plane of the neural plates, about half an inch, for example, in an extent of three inches; thus indicating a very depressed form of carapace.

The xiphisternal bone, like that of *Chel. breviceps*, is relatively broader than in the existing turtles, and both the internal and external margins of its posterior half are slightly toothed. A part of the notch by which it was attached to the hyposternal remains upon the broken anterior extremity of the bone. It measures one inch two lines across its broadest part; its length seems to have been three inches and a half.

The humerus presents the usual characters of that of the *Chelones;* its length is two inches three lines; its breadth across the large tuberosities ten lines. The radius and ulna extend in this Chelonite from beneath the carapace into the right orbit; the radius is one inch and a half in length; the ulna one inch, three lines in length; portions of vertebræ adhere also to the mass, the state of which indicates that the animal had been buried in the clay before the parts of the skeleton had been wholly disarticulated by putrefaction.

A mass of Sheppey clay-stone supporting the ninth and tenth neural plates, and the expanded portions of the sixth, seventh, and eighth costal plates of the right side, exhibits the characters of the marine turtles in the great relative expansion of the

tenth neural plate; and the tooth-like continuation of the rib from the posterior angle of the eighth costal plate. These portions of the carapace, from their smooth surface, the impressions of the horny scutes, the form of the vertebral ends, and the concavity of the upper surface of the costal plates, evidently belong to the same species as the fossil last described.

A similar mass of Sheppey clay-stone, in Mr. Lowe's collection, supports a larger proportion of the hinder part of the carapace, including the sixth, seventh, eighth, ninth, and tenth neural plates, part of the fifth neural plate, more or less of the last four pairs of costal plates, with the impressions of the third and fourth ribs of the right side; the impression of apparently the whole of the free, slender, termination of the third rib is preserved, and also that of the fifth rib, confirming the generic characters indicated by the skull. The smooth outer surface of the bones of the carapace, the forms of the neural plates, and the concomitant modification of the commencement of the costal plates articulated therewith, concur to establish the specific distinction from the *Chelone breviceps*, and indicate the specimen to belong to the present species, *Chelone longiceps*. The seventh, eighth, and ninth neural plates progressively decrease in size; and the ninth presents a simple, quadrangular, oblong form; the tenth neural plate suddenly expands, and has apparently a triangular form, but its posterior border is incomplete.

The indications of the comparative flatness of the carapace of the *Chelone longiceps*, (in this respect, as in the elongated and pointed form of the skull, approaching the genus *Trionyx*,) which were derived from an examination of the foregoing fragments, and particularly of the portion preserved with the cranium on which the species is founded, are fully confirmed by the almost entire carapace and plastron (Pl. 13) which, subsequently to the publication of my 'Report on British Fossil Reptiles,' where the present species is first noticed, I have had the opportunity of examining in the collection of Mr. Bowerbank.

This carapace, as compared with that of the *Chelone breviceps* in the same collection, presents the following differences:—it is much broader and flatter. The neural plates are relatively broader; the lateral angle from which the intercostal suture is continued, is much nearer the anterior margin of the plate—the *Chelone longiceps*, in this respect, resembling the existing species of turtle (see fig. 1, p. 3). The costal plates are relatively longer; they are slightly concave transversely to their axis on their upper surface, while in *Chel. breviceps* they are flat. The external surface of the whole carapace is smoother; and although it is as depressed as in most turtles, it is more regularly convex; not sloping away by two nearly plane surfaces from the median longitudinal ridge of the carapace.

The following minor differences may be noticed in the two Sheppey Chelonites: the nuchal plate of the *Chel. longiceps* (Pl. 13, fig. 1, I) is more convex at its middle part, and sends backwards a short emarginate process to join the first neural

plate (2); in which it resembles the *Chel. mydas.* The second neural plate (3) is pentangular, the left anterior corner being produced, and truncate to join with the first costal plate of the left side; the right posterior corner of the first neural plate (2) being produced, and truncate, to articulate with the second costal plate of the right side. This structure I believe, however, to be an individual variety. In another carapace of the *Chelone longiceps*, e. g. both posterior angles of the first neural plate are produced, and truncate to articulate with the second pair of costal plates; and the second neural plate is quadrangular. But the characters of the species are exemplified in more constant modifications of the carapace. The succeeding neural plates to the seventh inclusive (4—7) are hexagonal, with the anterior lateral border much shorter than the posterior lateral border, as in *Chelone mydas*, and not of equal extent, as in *Chelone breviceps;* they become more equal in the seventh (8) and eighth (9) neural plates, which also decrease in size; the ninth plate (10) is very small, quadrangular, and oblong, as in Mr. Lowe's fragment. Only a small portion of the last neural plate is preserved in Mr. Bowerbank's beautiful specimen.

The impressions of the horny scutes are deeper, and the lines which bound the sides of the vertebral scutes ($v1$—$v4$) meet at a much more open angle than in the *Chel. breviceps*, in which the vertebral scutes have the more regular hexagonal form of those of the *Chel. mydas.* Their relations to the neural plates are nearly the same as in *Chel. breviceps.*

The plastron (Pl. 13, fig. 2) is more remarkable than that of the *Chel. breviceps* for the extent of its ossification; the central cartilaginous space being reduced to an elliptical or subquadrangular fissure. The four large middle pieces *hyosternals* (*hs*) and *hyposternals* (*ps*), have their transverse extent relatively much greater as compared with their antero-posterior extent, than in the *Chel. breviceps;* and this might be expected, in conformity with the broad character of the bony cuirass indicated by the carapace. The median margins of the *hyosternals* (*hs*) are developed in short toothed processes, along their anterior three fourths; the median margins of the *hyposternals* (*ps*) have the same structure along nearly their whole extent; the intermediate space between the smooth or edentate margins of the opposite bone is ten lines; the expanded end of the long coracoid is seen projecting into this space.

The xiphisternals (*xs*) are relatively broader than in *Chel. breviceps*, or in any of the existing turtles; and are united together, or touch each other, by the toothed processes developed from the whole of their median margins. The entosternal piece is broad, flat on its under surface, and is likewise dentated at its sides.

The outer surface of each half of the plastron inclines, as in the *Chelone mydas*, towards a submedian longitudinal ridge.

The breadth of the plastron, in the specimen figured (fig. 2), along the median suture, uniting the hyosternals and hyposternals, is six inches: the narrowest antero-posterior diameter of the conjoined hyosternals and hyposternals is two inches nine lines

The breadth of the plastron, at the junction of the xiphisternals with the hyposternals, is two inches six lines.

The posterior part of the cranium is preserved in Mr. Bowerbank's specimen (fig. 1), withdrawn beneath the anterior part of the carapace; the fracture shows the osseous shield covering the temporal fossæ; and the pterygoids remain, exhibiting the deep groove that runs along their under part.

It is most satisfactory to have found that the two distinct species of the genus *Chelone*, determined, in the first instance, by the skulls only, should thus have been confirmed by the subsequent comparison of their bony cuirasses; and that the specific differences, manifested by the cuirasses, should be proved by good evidence to be characteristic of the two species founded on the skulls.

Thus the portion of the skull preserved with the carapace first described (Pl. 17, fig. 6), served to identify that fossil with the more perfect skull of the *Chelone breviceps* (Pl. 17, *A*), by which the species was first indicated. And, again, the portion of the carapace adhering to the perfect skull of the *Chelone longiceps* equally served to connect with it the nearly complete osseous buckler (Pl. 13, fig. 1), which, otherwise, from the very small fragment of the skull remaining attached to it, could only have been assigned conjecturally to the *Chel. longiceps;* an approximation which would have been the more hazardous, since the *Chelone breviceps* and *Chelone longiceps* are not the only turtles which swam those ancient seas that received the enormous argillaceous deposits of which the Isle of Sheppey forms a part.

Chelone latiscutata. *Owen.* Plate 24.

Proceedings of the Geological Society of London, December 1, 1841, p. 574. Report on British Fossil Reptiles, Trans. British Association, 1841, p. 179.

A considerable portion, measuring three inches in length, of the bony cuirass of a young turtle from Sheppey, including the first to the sixth neural plates (Pl. 24, fig. 1, *s*1—*s*6), with the corresponding pairs of costal plates (*pl*1—*pl*6), and the hyosternal (fig. 2, *hs*) and hyposternal (*ps*) elements of the plastron, most resembles that of the *Chelone longiceps* in the form of the carapace, and especially in the great transverse extent of the above-named parts of the plastron: it differs, however, from the *Chel. longiceps*, and the other known fossil Chelonites, in the greater relative breadth of the vertebral scutes (*v*2, *v*3), which are nearly twice as broad as they are long.

The central vacuity of the plastron is subcircular; and, as might be expected, from the apparent nonage of the specimen, is wider than in the *Chel. longiceps;* but the toothed processes given off from the inner margin of both hyosternals and hyposternals are small, sub-equal, regular in their direction, and thus resemble those of the *Chel. longiceps;* the slender point of the episternal (*s*) is preserved in the interspace between

the hyosternals. Both hyosternals (*hs*) and hyposternals (*ps*) are slightly bent upon a median longitudinal prominence of their under surfaces.

The length of the third costal plate (*pl*3) is one inch seven lines; its antero-posterior diameter or breadth, six lines: in the form of the vertebral extremities of the costal plates, and of the neural plates to which they are articulated, the present fossil resembles the *Chel. longiceps;* but the fifth neural plate is more convex, and is crossed by the impression dividing the third vertebral scute (*v*3) from the fourth, which impression crosses the suture between the fifth and sixth neural plates in both *Chelone longiceps* and *Chelone breviceps.* Whether, in the progressive change of form, which the vertebral scutes may have undergone in the growth of this young turtle, as during the growth of the young loggerhead turtle (*Chelone caouanna*), by an increase of length, without corresponding increase of breadth, the impression between the third and forth vertebral scute, might also retrograde to the interval between the fifth and sixth neural plates, I am uncertain, having only had the opportunity of comparing the scutes of the young and old loggerhead turtles, not the skeletons. The change in the lateral angles of the vertebral scutes, resulting from the elongation of the scutes themselves, in the loggerhead turtle, would be similar to that in the *Chelone longiceps*, as compared with the *Chel. latiscutata,* on the hypothesis that the latter is the young of the former; but in my present uncertainty I prefer to indicate the specimen in question, by the definite name proposed in my original Memoir; its description as a distinct species being more likely to attract the attention of Collectors to similar specimens, and to enable them to identify such. Figure 3 gives the degree of convexity of the carapace, and the double curve of the plastron produced by the prominence of the principal hæmapophyses *hs* and *ps*. The left scapular arch (51) is exposed in this view.

CHELONE CONVEXA. *Owen.* Plate 14 and Plate 24, fig. 4.

Proceedings of the Geological Society of London, December 1, 1841, p. 575. Report on British Fossil Reptiles, Trans. British Association, 1841, p. 178.

The fourth species of *Chelone*, indicated by a nearly complete cuirass, from Sheppey, holds a somewhat intermediate position between the *Chelone breviceps* and the *Chelone longiceps;* the carapace being narrower, and more convex than that of *Chel. longiceps;* broader and with a more regular transverse curvature than in the *Chelone breviceps.*

Although the specimen is equal in size to either of the two with which it is here compared, the costal plates hold an intermediate length, which shows that this character is not due to a difference depending upon age.

The fossil in question includes the first to the eighth neural plate inclusive; the first plate (2) expands behind, and both posterior angles are truncated to articulate with the second costal plates (*pl*2). The second neural plate (3) is quadrate, half as long again as broad, and the second pair of costal plates articulate with this, as well

as with the first and third plates, as in the specimen of *Chel. longiceps* noticed at p. 19. The tooth-like extremity of the connate rib is preserved on the right side. The fourth costal plate (*pl*4) is two inches four lines in length, nine lines in breadth; the angle at which the expanded part contracts to the extremity of the connate rib is well shown on the right side. The third to the eighth neural plates expand anteriorly, and have the anterior angles cut off to articulate with the costal plates in advance; they diminish in size very gradually, and the antero-lateral borders, formed by the above-named truncated angles, do not increase in length as in the corresponding plates in the *Chelone longiceps.*

The vertebral scutes (*v*2, *v*3, *v*4) resemble more in form those of the *Chel. longiceps* than of *Chel. breviceps;* but, notwithstanding that the whole carapace is narrower than in *Chel. longiceps,* the vertebral scutes are broader; and the lines which converge to the lateral angle have a more marked sigmoid curvature.

	Chel. convexa.		*Chel. longiceps.*	
	Inches.	Lines	Inches.	Lines.
The length of the second vertebral scute is	1	8	1	8
Breadth	2	6	2	2

The two succeeding scutes (*v*3 and *v*4) more rapidly diminish in size than in either the *Chel. breviceps* or *longiceps,* and the transverse impression between the third and fourth vertebral scute crosses the lower third of the fifth neural plate, as in *Chelone latiscutata.* All the scutes have left deeper and rather wider impressions than in the preceding species.

The second to the fifth costal plates inclusive, are more equal in length than in the existing *Chelone mydas* or *Chel. caouanna,* and in this character the present species more resembles the *Chel. imbricata.*

The distinction of the present from the previously described fossils, already manifested in the structure of the carapace and the form of the vertebral scutes, is more strikingly established in that of the plastron (Pl. 14, fig. 2), which, in its defective ossification, resembles the same part in the existing species of *Chelone.*

All the bones, but especially the xiphisternals (*xs*), are more convex on their outer surface than in other turtles, recent or fossil. The central vacuity is greater than in any of the above-described fossil species. The internal rays of the hyosternals come off from the anterior half of their inner border, and are divided into two groups: the lower consisting of two short and strong teeth, projecting inwards towards the extremity of the entosternal (*s*); while the rest extend forwards along the inner side of episternals (*es*). The same character may be observed in the corresponding processes of the *hyposternals* (*ps*), which are limited to the posterior half of their inner border. The external radiated process of the hyosternals (*hs*) arises from a larger proportion of the outer margin, than in the *Chel. mydas;* but from a somewhat less proportion than in *Chel. breviceps.*

The external process of the hyposternal (*ps*) is relatively much narrower than in the *Chel. breviceps* (Pl. 16, fig. 2), and, *à fortiori*, than in *Chel. longiceps* (Pl .13, fig. 2). The straight transverse suture by which the hyosternals and hyposternals of the same side are joined together, is much shorter than in the other fossil *Chelones;* and is similar in extent to that in *Chel. mydas;* but the following differences present themselves in the plastron of the *Chelone convexa*, as compared with that of the *Chelone mydas*.

The median margin of the hyosternals forms a gentle curve, not an angle: that of the hyposternals is likewise curved, but with a slight notch. The longitudinal ridge on the external surface is nearer the median margin of the *hyosternals* and *hyposternals* and is less marked than in the *Chelone longiceps;* especially in the hyposternals, which are characterised by a smooth concavity in the middle of their outer surface.

The suture between the *hyosternals* and *hyposternals* is nearer to the external, transverse, radiated process of the hyposternals. The median vacuity of the sternal apparatus is elliptical in the *Chel. convexa*, but square in the *Chel. mydas*.

The characteristic lanceolate form of the episternal bone (*s*) in the genus *Chelone*, is well seen in the present fossil. The entosternal element of the plastron is subcircular, or lozenge-shaped; and generally broader than it is long in the Emydians.

The true marine character of the present Sheppey Chelonite, so well given in the carapace and plastron, is likewise satisfactorily shown in the small relative size of the entire femur (65) which is preserved on the left side, attached by the matrix to the left xiphisternal. It presents the usual form, and slight sigmoid flexure, characteristic of the *Chelones;* it measures one inch in length.

In an *Emys* of the same size, the femur, besides its greater bend, is one inch and a half in length.

A Chelonian cranium from Sheppey, two inches five lines in length, in the museum of Professor Bell (Pl. 24, fig. 4), and a second of the same species from the same locality, two inches nine lines in length (Pl. 25, figs. 1, 2, and 3), in the museum of Fred. Dixon, Esq., F.G.S., belong to the same species, and differ from the cranium of the *Chelone breviceps*, in the more pointed form of the muzzle, and the less rugose character of the outer surface of the bones; they equally differ from the *Chelone longiceps* in the less produced, and less acute muzzle, and the more rugose surface of the bones. The parietals (7) are bounded anteriorly by a semicircular line, not by a semioval one, as in *Chel. longiceps*, or by an angular one, as in *Chel. breviceps*. The frontals (11) enter into the formation of the orbits, as in both the foregoing species. The orbits are subcircular, as in *Chel. longiceps*, not subrhomboidal with the angle rounded off, as in *Chel. breviceps*. The postfrontals (12) are large, and form a slight projection at the back part of the supraorbital ridge. The tympanic cavity is larger in proportion than in the *Chelone longiceps*. The palate is traversed by a deep median, longitudinal groove, between which and the shallower grooves on the inner sides of the alveolar borders, are two well-marked, diverging, longitudinal prominences. The bony palate is longer than in *Chelone breviceps*, shorter than in *Chel. longiceps*.

The symphysis of the lower jaw (Pl. 14, fig. 3) is longer or deeper than in the *Chelone breviceps,* but is convex below from side to side, and not flattened as in the *Chelone planimentum.*

All the specimens of *Chelone convexa,* which I have been able to determine, are from the London clay of Sheppey.

CHELONE SUBCRISTATA. *Owen.* Plate 15.

Proceedings of the Geological Society of London, December 1, 1841, p. 576. Report on British Fossil Reptiles, Trans. British Association, 1841, p. 179.

The fifth species of *Chelone* from Sheppey, distinguishable by the characters of its carapace, approaches more nearly to the *Chelone caouanna* in the form of the vertebral scutes (*v*1—*v*4), which are narrower in proportion to their length, than in any of the previously described species; but the *Chelone subcristata* is more conspicuously distinct by the form of the fifth and seventh neural plates (6, 8), each of which supports a short, sharp, longitudinal crest; a similar crest is developed from the contiguous ends of the second and third neural plates (3, 4); the middle and posterior part of the nuchal plate (1) is raised into a convexity, as in the *Chel. longiceps;* but not into a crest.

The keeled structure of the above-cited neural plates is more marked than in the third and fifth neural plates of *Chelone mydas,* which are raised into a longitudinal ridge.

The neural plates in the present carapace have the ordinary, narrow, elongated form of those in the true *Chelones.* The nuchal plate (1) has the middle of its hinder border produced backwards, instead of being emarginate, as in the *Chel. breviceps* (Pl. 16, fig. 1, *ch*).

The first neural plate in the *Chelone subcristata* (Pl. 15, 2) resembles that in the *Chelone convexa,* but is narrower in proportion to its length; the second (3) is also quadrangular, as in *Chel. convexa,* but is narrower; the third to the seventh likewise differ from those in *Chel. convexa* only by being narrower; but the eighth and ninth neural plates are relatively smaller than in any of the before-described fossils, and resemble those of existing *Chelones.* The expanded plate is more elevated, and is bent down on each side, with the middle part forming an obtuse longitudinal ridge. A part of the contiguous portion of the first (*pl*1) and the second (*pl*2) costal plates are raised into a slight convex eminence on each side; the surface of the remaining pairs of ribs is flat in the axis of the body, but they are more convex transversely to that axis, and in the direction of their own length, than in the other Chelonites.

The whole outer surface of the bones of the carapace is as smooth as in the *Chel. longiceps* and *Chel. convexa.*

Subjoined are comparative lengths of the carapace from the first to the eighth neural plate inclusive:

Ch. subcristata.		*Ch. breviceps.*		*Ch. longiceps.*		*Ch. convexa.*	
Inches	Lines.	Inches	Lines.	Inches.	Lines.	Inches.	Lines.
7	4	5	6	5	9	5	8

The length of the present fossil carapace, to the tenth neural plate, inclusive, is nine inches.

The breadth between the ends of the third costal plates, in a straight line, is six inches six lines. The succeeding costal plates more gradually decrease in breadth, than in the *Chel. longiceps* and *Chel. convexa ;* and the entire carapace more resembles in form that of the *Chel. mydas,* and *Chel. caouanna.*

The epidermal scutes are defined by deep impressions, and as wide, relatively, as in the *Chel. mydas* and *Chel. convexa.* The length of the second vertebral scute is two inches one line ; its breadth is two inches two lines ; the length of the fourth vertebral scute is two inches three lines ; and its breadth one inch eleven lines, and, at its posterior margin, only nine lines. This scute is narrower than in *Chel. caouanna,* or any of the previously described fossil species ; the outer angles are less produced than in the *Chelone caouanna.*

Sufficient of the plastron is exposed in the present fossil to show by its narrow elongated xiphisternals (*xs*), and by the wide and deep notch in the outer margin of the conjoined hyosternals and hyposternals (*hs* and *ps**), that it belongs to the marine *Chelones.* The xiphisternals are articulated to the hyposternals by the usual notch or gomphosis ; they are straighter and more approximated than in the *Chel. mydas* and *Chel. caouanna.* The external emargination of the plastron between the hyosternals and hyposternals, differs from that of the recent turtles in being semicircular, instead of angular ; the *Chel. subcristata* approaching, in this respect, to the *Chel. breviceps.* The shortest antero-posterior diameter of the conjoined hyosternals and hyposternals is two inches seven lines. The length of the xiphisternal is two inches six lines ; the breadth of both, across their middle part, is one inch three lines.

The name proposed for this species indicates its chief distinguishing character, viz., the median interrupted carina of the carapace, which may be presumed to have been more conspicuous in the horny plates of the recent animal, than in the supporting bones of the petrified carapace.

Chelone planimentum. *Owen.* Plates 18, 19, and 19*A.*

Proceedings of the Geological Society of London, December, 1841, p. 576. Report on British Fossil Reptiles, Trans. British Association, 1841, p. 178.

Syn. Chelone Harvicensis, *Woodward* (?).

The skull of a large *Chelone* (Pl. 18) from the Eocene clay near Harwich, in Professor Sedgwick's collection at Cambridge, resembles, in the pointed form of the muzzle, the *Chel. longiceps* of Sheppey ; but differs in the greater convexity and breadth of the cranium (fig. 2) ; and the more abrupt declivity of its anterior contour (fig. 1), and from other *Chelones* by the broad expanse of the inferiorly-flattened *symphysis menti* (fig. 3).

* Refer to fig. 3, p. 4, for these letters.

The osseous roof of the temporal fossæ, and the share contributed to that roof by the postfrontals (Pl. 18, figs. 1 and 2, 12), distinguish the present, equally with the foregoing Chelonites, from the *Emys* (*Podocnemys*) *expansa*, and, *à fortiori*, from other genera and species of the fresh-water families (*Emydidæ* and *Trionicidæ*).

In the oblique position of the orbits (fig. 2), and the diminished breadth of the interorbital space (fig. 1), the present Chelonite, however, approaches nearer to *Trionyx* and *Emys* than do the previously-described species. But the sides of the face converge more rapidly towards the muzzle. Its most marked and characteristic difference from all existing *Chelones* is shown by the greater antero-posterior extent, breadth, and flatness of the under part of the symphysis of the lower jaw (fig. 3), whence the specific name here given to the species. The posterior border of the symphysis is defined by a regular semicircular curve, and the rami of the jaw have completely coalesced.

Since at present there is no means of identifying the well-marked species, of which the skull is here described, with the Chelonite figured in the frontispiece to Woodward's 'Synoptical Table of British Organic Remains,' and alluded to, without additional description or characters, as the *Chelonia Harvicensis*, in the additions to Mr. Gray's 'Synopsis Reptilium' (p. 78, 1831); and since the extensive deposit of Eocene clay along the coast of Essex, like that at the mouth of the Thames, contains the relics of more than one species of ancient British turtles,* I prefer indicating the one here established by a name having reference to its peculiarly distinguishing character, rather than to associate arbitrarily the skull, which gives the true specific distinction, with the ill-defined carapace to which the vague name of *Harvicensis* has been applied; more especially as the fossil carapace to which the present skull more probably belongs, from the circumstance under which it was discovered, also presents well-marked, and readily-recognisable specific characters.

This carapace (Pl. 19) is also contained in the museum of Professor Sedgwick, and is understood to have formed part of the same individual turtle as the skull (Pl. 18) on which the species, *Chel. planimentum*, was founded.

In general form this carapace differs from that of the existing *Chelones*, in being less contracted and pointed posteriorly than in the *Chelone mydas* and *Chel caouanna*, and more contracted posteriorly than in the *Chel. imbricata*. In the proportion which the pleurapophyses (true ribs), bear to the superimposed costal plates, (*pl*4—8) it resembles *Chelone mydas*, and *Chelone caouanna*, more than it does the *Chel. imbricata*. But the pleurapophyses are more prominent and distinct from the costal plates throughout their entire length, than in the *Chel. mydas* or *Chel. caouanna*, and present an obtuse angular ridge towards the cavity of the abdomen.

The five posterior pairs of ribs of the carapace (*pl*4—*pl*8) are preserved, with part

* Sir C. Lyell alludes to the Chelonites of Harwich in his 'Elements of Geology:' "This formation is well seen in the neighbouring cliffs of Harwich, where the nodules contain many marine shells, and sometimes the bones of Turtles." (Vol. ii, p. 337.)

of the first three on the left side, and one of the coracoids showing the rather sudden and considerable expansion of its sternal or mesial half.

The interval between the free extremities of most of the ribs, is about equal to twice and a half the breadth of each extremity; but the interval between the seventh (*pl7*) and eighth (*pl8*) rib, measured, like the others, at the terminal border of the costal plates, is equal to thrice the breadth of the free part of the seventh rib.

In this respect the *Chelone planimentum* resembles the *Chel. mydas* more than it does the *Chelone caouanna*, in which the interval between the free extremities of the seventh and eighth ribs is less than that between the sixth and seventh. The length of the costal plate of the fourth rib is twice that of the eighth rib, as in the *Chelone caouanna;* in *Chel. mydas* it is more than twice as long; in *Chel. imbricata* it is only one third longer. The marginal pieces in the *Chelone planimentum* seem to have been narrow or slender in proportion to their length.

The following admeasurements show that, in the large proportionate size of the head, the *Chelone planimentum* corresponds with the existing turtles:

	Inches.	Lines.
Length of the cranium	5	6
Depth of ditto	4	0
Breadth of ditto	5	0
Length of the carapace	15	6
Greatest breadth of ditto	13	0

Plates 18 and 19 satisfactorily illustrate the characteristic forms and proportions of the unique specimen in the Cambridge Museum; the carapace is figured of its natural size, and shows its inner surface.

CHELONE CRASSICOSTATA. *Owen.* Plates 20, 21, 22, 22*A*, and 22*B*.

TESTUDO PLANA. *König.* 'Icones Sectiles,' Pl. XVI, fig. 192?

That the extinct species of Eocene turtles attained larger dimensions than those given above, is proved by a fossil skull from the Harwich clay, in the collection of Professor Bell, which gives the following dimensions:

	Inches.	Lines.
Total length of the cranium	8	0
Its greatest breadth	6	0
The antero-posterior extent of the *symphysis menti*	3	0
The vertical diameter of the orbit	1	9
do. do. of the nostril	0	9

This skull differs from that of the *Chelone planimentum* in the minor depth of the maxillary bone below the orbit (compare Pl. 18, fig. 1, with Pl. 20, fig. 2), in the more acute and attenuated muzzle; but especially in the minor breadth and the different configuration of the posterior margin of the *symphysis* of the lower jaw (compare Pl. 18,

fig. 3, with Pl. 20, fig. 3). With regard to the comparative anatomy of the bones of the skull, and the pattern of the scutation of the upper surface of the cranium, I regret that the state of the specimen in Professor Bell's collection does not permit the deduction of other distinctive characters which such parts of the cranial organization so satisfactorily afford. A great proportion of the osseous parietes is wanting; but the cast in the hard matrix of the wide lateral cavities (12, 12), which were over-arched by the expanded postfrontal and parietal bones, indicates the prominence of the postfrontals at the upper and outer angle of the orbits. The orbits (*or*) appear to have been more ovate and less circular than in the *Chelone planimentum;* and the sides of the orbital part of the skull do not converge so rapidly towards the muzzle, but meet at a more acute angle.

That a second species of turtle, distinct from the *Chelone planimentum,* has left its remains in the Harwich clay, is very decisively demonstrated by the almost complete carapace in the British Museum, the inner surface of which is represented, on the scale of six inches to a foot, in Pl. 21. This carapace, both by its general contour, by the relative length of the costal plates to one another, and by their relative breadth to the adherent pleurapophyses beneath, more resembles the carapace of the *Chelone imbricata* than that of the other known existing species of turtle; and, as the peculiar characters of the *Chelone imbricata* are exaggerated, it differs in a proportional degree from the *Chelone planimentum.* These characters are seen in the great breadth of the prominent inferior part of the ribs, and of the free extremity of the rib (*pl*1—*pl*8), as compared with the total breadth of the costal plate. The intervals between the free extremities, where the expanded plate terminates, are not equal to the breadth of the proper ribs; in the *Chelone imbricata* they very slightly exceed the breadth of the free ends of the ribs. This character in the fossil, by which it is so markedly distinguished from the *Chelone planimentum,* and most other species, has suggested the name *Chelone crassicostata,* or thick-ribbed turtle, which is proposed for the present species. The last pair of ribs of the carapace (Pl. 21, *pl*8) are remarkably short and thick, and are curved backwards on each side the broad terminal neural plates which they almost touch. In this character the *Chel. crassicostata* resembles the *Chel. imbricata,* and differs from the *Chel. caouanna* (fig. 2, p. 3), and from *Chel. mydas.* The subequality of length of the costal plates is another character by which the *Chel. crassicostata* resembles the *Chel. imbricata,* and differs from the *Chel. mydas,* the *Chel. caouanna,* as well as from the *Chel. planimentum.*

In Pl. 21, as in the other figures, *ch* is the nuchal plate, *pl*1 the first rib of the carapace (the second free pleurapophysis or vertebral rib), *pl*2 to *pl*8 the remaining ribs of the carapace and costal plates; *s*9, *s*10, and *py* are the terminal neural plates and pygal plate, which, like the nuchal plate, are developed in the substance of the integument, without becoming attached to the subjacent spinous processes of the vertebræ. The debris of the neural arches of the intermediate eight vertebræ of the

carapace are preserved in the interspaces of the beginnings of the ribs and costal plates in this beautiful Chelonite. It forms part of the Fossil Collection in the British Museum.

A carapace of a smaller individual of *Chelone crassicostata,* from the Harwich coast, with the character of the broad and inwardly-prominent ribs strongly marked, is likewise preserved in the choice collection of my esteemed friend Professor Bell. One of the hyosternal bones, inclosed in the same nodule of clay, testifies to the partial ossification of the plastron in this species by its coarsely-dentated border; and, at the same time, shows a specific peculiarity by the convexity of that surface which was turned towards the cavity of the thoracic-abdominal case. On the moiety of the nodule containing the carapace and exposing its under surface, the slender rudimental rib of the proper first dorsal vertebræ is preserved, in connexion with the first expanded rib of the carapace.

Besides the specimen of *Chelone crassicostata* from Harwich, figured in Pl. 21, there is a mutilated carapace of a young *Chelone,* from the same locality, in the British Museum. This specimen exhibits the inner side of the carapace, with the heads, and part of the expanded bodies, of four pairs of ribs, which indicate its specific agreement with the foregoing specimen, and demonstrate unequivocally its title to rank with the marine turtles. It is figured in Mr. Kœnig's '*Icones Sectiles*' (pl. xvi, fig. 192), under the name of *Testudo plana.*

A rare Chelonite from the hard Eocene clay apparently of Harwich, in the collection of my friend Frederick Dixon, Esq., F.G.S., of Worthing, shows the impressions from the under surface of the carapace, and also an instructive part of the under surface of the plastron itself. (Pl. 22.) The proportions and degree of convexity of the under surface of the costal plates of the carapace (*pl, pl*) correspond with those parts in the *Chelone crassicostata.*

The remains of the plastron include a great portion of the left hyosternal (*hs*), left hyposternal (*ps*), and left xiphisternal (*xs*); the latter is articulated to the hyposternal by a notch, receiving a toothed process, and, reciprocally, near the upper part of a long oblique harmonia, between the outer border of the hinder angle of the hyposternal and the inner border of the upper half of the xiphisternal. The hyosternal is concave lengthwise, and is convex across on its under surface; the transverse linear impression, dividing the pectoral and abdominal scutes, crosses near its posterior border. The degree of concavity of the outer surface of this bone corresponds with the convexity of the upper and inner surface of the same bone in the specimen of the *Chelone crassicostata* from Harwich, in the Museum of Professor Bell; and it concurs with the characters of the costal plates in proving the present Chelonite to be of the same species. Impressions of the toothed mesial margin of the right hyosternal remain, and part of the toothed margin of the left hyposternal.

The right coracoid (52) is exposed by the removal of the right hyosternal; it differs in form from that preserved in the large specimen of *Chelone planimentum*, in Professor Sedgwick's Museum, in expanding less suddenly at its sternal end, as compared with the coracoid of the *Chelone mydas*, or with that of the *Chelone caouanna*, which is somewhat broader than in the *Chel. mydas;* the coracoid of the *Chel. crassicostata* agrees with that of the *Chel. planimentum* in the greater degree of its expansion. At the anterior fractured surface of Mr. Dixon's Chelonite, the long and slender columnar or rib-like scapula, is shown, extending from the under part of the head of the second costal rib downwards and outwards, for an extent of two inches, and then sending its acromial or clavicular prolongation at the usual open angle downwards and inwards to rest upon the episternal. The proportions of these parts of the scapular arch are quite those which characterise the genus *Chelone*, but they do not supply such marks of specific distinction as the coracoid element does.

Chelone declivis. *Owen.* Plate 23.

The extinct turtle represented by this specimen, and indicated by the above term, bears the same relation to the *Chelone convexa*, which the *Chelone longiceps** does to the *Chelone latiscutata*;† that is, it has the same general characters of the petrified parts of the carapace, but differs in the narrower proportions of the vertebral scutes (*v*1—*v*4), and the more open angle at which their two lateral borders meet; the vertebral angles of the costal scutes being correspondingly less acute.

The specimen is from the Eocene deposits of Bognor, Sussex, and is preserved in the collection of Frederick Dixon, Esq. It consists of the seven anterior neural plates, and the corresponding seven pairs of costal plates (Pl. 23, fig. 1), those of the right side having been broken away from their attachments to the neural plates, and bent upon the rest of the carapace at an acute angle with some slight separation of the sutures of the costal plates (fig. 2).

The neural plates correspond in general form with those of the *Chelone convexa*, the hind ones being rather broader; the first (*s*1) is crossed at its middle part by the impression dividing the first (*v*1) from the second (*v*2) vertebral scute; the second neural plate (*s*2) is an oblong four-sided one, with both ends of equal breadth. The third neural plate, *s*3, resumes the hexagonal figure with the broadest end, and two shortest sides at the fore part; and is crossed in its lower half by the impression dividing the second, *v*2, from the third vertebral scute, *v*3. The fifth neural plate (*s*5) is crossed by the next transverse impression nearer its lower border. The sixth and seventh neural plates retain the same form and proportions as in the *Chelone convexa*, except a somewhat

* Proceedings of the Geological Society of London, December 1, 1841, p. 572.

† Ibid., p. 574.

greater breadth, and have not their antero-lateral borders increased in length, as in the *Chelone longiceps*.

The declination of the ribs from the neural plates, gives a greater degree of steepness to the sides of the carapace than in the *Chelone convexa*, and the impressions of the scutes have equal depth and breadth. The chief difference indicative of specific distinctions, lies in the form of those impressions; and the question is, whether, in the progress of growth which makes the longitudinal extent of two of the vertebral scutes in one specimen nearly equal to three, in another, so great a change could be effected in their shape as is shown in the specimen of *Chelone convexa;* in which it will be seen that the second vertebral scute (Pl. 14, fig. 1), though one third shorter than in *Chel. declivis* (Pl. 23, *v*2), is of the same breadth as that in the larger specimen, and that the rest differ in the same remarkable degree.

Fig. 3 shows the characteristic declivity of the sides of the carapace in the present species.

Chelone trigoniceps. *Owen.* Plate 25, figs. 4, 5, and 6.

More than one of the old tertiary turtles (*Chelone*) are remarkable for the longitudinal extent or depth of the symphysis of the lower jaw.

The turtles from the Eocene clay at Harwich have this character so strongly developed and the under surface of the symphysis so flattened, especially in one of the species (Pl. 18), as to have suggested the "nomen triviale" *planimentum* for it. The *Chelone longiceps* (Pl. 12), if we may judge by the length of the upper jaw and bony palate, must have had a corresponding extent of the symphysis of the under jaw; and we may infer the same peculiarity from the straight alveolar borders of the maxillaries and their acute convergence towards the premaxillary bones in an allied species, *Chelone trigoniceps*, which I have described and figured in the Appendix to Mr. Dixon's work on the 'Fossils of Sussex,' from a specimen which is in the collection of G. A. Coombe, Esq., and which was obtained from the Eocene clay at Bracklesham.

Amongst the Chelonites which Mr. Dixon has obtained from the same formation and locality, are portions of the fore part of the lower jaw of four individuals of the genus *Chelone*, all exhibiting the characters of the pointed form and great depth of the symphysis.

One of these specimens (Pl. 18, figs. 5 and 6) agrees so closely in size and shape with the fore part of the upper jaw of the *Chelone trigoniceps* (fig. 4)—fits, in fact, so exactly within the alveolar border, and so closely resembles that specimen in texture and colour, that, coming from the same formation and locality, and being obtained by the same collectors, I strongly suspect it to belong to the same species of *Chelone*, if not to the same individual.

The known recent *Chelones* differ among themselves in the shape and extent of the bony symphysis of the lower jaw. Both the *Chelone imbricata*, and *Chelone caouanna*

have this part deeper and more pointed than the *Chel. mydas,* but neither species has the symphysis so depressed or so slightly convex below as it is in the Bracklesham *Chelones.*

These also differ amongst themselves in this respect. The symphysis (figs. 5, 6, 11) which I have referred to the *Chelone trigoniceps,* is the broadest and flattest; at its back part (fig. 7) it shows a deep and broad genio-hyoid groove; this is reduced to a transversely oblong foramen in *Chelone mydas.*

The second species from Bracklesham, is indicated by the maxillary symphysis (fig. 9), the sides of which meet at a more acute angle, and it is narrower in proportion to its length, is more convex below, and more concave above, with the alveolar borders a little more raised, and the middle line less raised than in *Chelone trigoniceps.* In this respect it is intermediate between the *Chelone imbricata,* where the upper surface of the symphysis is more concave, and the *Chelone caouanna,* where it is flatter than in the *Chelone trigoniceps.* The fossil symphysis under notice, has also a smooth, transverse, genio-hyoid groove at its back part. It accords so closely in form with the end of the upper jaw of the *Chelone longiceps,* from Sheppey, that I refer it provisionally to that species.

Two other specimens of the symphysis of the lower jaw (figs. 8, 10), of rather larger size, appear to belong to the same species as that referred to the *Chel. longiceps,* by the characters of the concavity of the upper surface, the convexity of the lower surface, and the degree of convergence of the sides or borders of the symphysis. The larger of the two shows the genio-hyoid groove, and the nearly vertical outer side of the jaw, opposite the back part of the symphysis, and this shows no impression of the smooth fossa receiving the insertion of the biting muscles, whereas, in the *Chelone trigoniceps,* fig. 11, that fossa extends to the same transverse line or parallel with the back part of the symphysis.

The very rare and interesting Chelonite in Mr. Coombe's museum (fig. 4) was the first portion of the cranium of a reptile of this order that I had seen from the Eocene deposits at Bracklesham. It includes the bones forming the roof of the mouth, with portions of the bony nostrils and orbits, and the tympanic pedicles.

The extremity of the upper jaw is broken off, but the straight converging alveolar borders clearly indicate the muzzle to have been pointed, as in the *Chelone longiceps* of Sheppey; and the muzzle being shorter, the form of the skull has more nearly approached that of a right-angled triangle. The whole cranium is broader and shorter, and the tympanic pedicles wider apart. The middle line of the palate developes a somewhat stronger ridge; the orbits were relatively larger and advanced near to the muzzle: the malar bones are more protuberant behind the orbits, and their external surface inclines inwards as it descends from behind and below the orbit, to form the lower border of the zygoma, which it does not do in the *Chelone longiceps.*

The upper surface of the fossil shows the palatines rising to form the vomer at the middle line, and the two small subcircular vacuities (occupied by membrane in the

recent skull) between the palatines, prefrontals, and maxillaries; the anterior border of the temporal fossa, formed by the malar and pterygoid, is entire on one side, and shows that that vacuity was as broad as it is long. The olfactory excavations in the maxillaries are deep. The articular surface of the tympanic pedicles closely accords with those of recent *Chelones*. The very regular triangular form of the skull indicated by this fragment, has induced me to propose the name of *Chelone trigoniceps* for the species.

Chelone cuneiceps. *Owen.* Plate 11.

One of the most complete and instructive crania of the fossil turtles of our Eocene deposits is the subject of Pl. 11, the opportunity of describing and figuring which has been kindly afforded me by J. Toulmin Smith, Esq., F.G.S., of whose cabinet it forms part, and by whose skilful manipulation its variously configurated exterior has been disencumbered of the hard adherent clay.

From the *Chelone breviceps* this specimen differs by its more prolonged and pointed muzzle; by the more sudden and sloping declivity of the prefrontal part of the cranium (fig. 1, 14); by the minor degree of rugosity of the surface of the bones; and by the different disposition of the superincumbent horny scutella, which is indicated by their impressions. In the general arrangement of these impressions it accords better with the cranium of the *Chelone longiceps;* but differs in the greater breadth of the skull as compared with its length; in the minor extent of the bony palate (fig. 3, 20, 21), the more advanced position of the posterior nostrils, and the greater length of the pterygoids (24). From the *Chelone convexa* it differs, in the greater relative breadth and flatness of the frontal bones, and of the whole interorbital platform (fig. 2, 11), in the downward slope of that part of the cranial profile, and in the more prominent convexities of the palatal processes of the maxillaries. From the *Chelone planimentum* it differs also, by the broader prefrontal part of the interorbital space, as compared with the transverse diameter of the back part of the skull; by the minor degree in which the frontal enters into the formation of the upper rim of the orbits; by the minor depth of the suborbital part of the maxillary and malar bones, and by a very different arrangement of the supracranial horny scutella.

The basi-occipital (Pl. 11, figs. 3 and 4) is remarkable for the strong development of the tubercles for the insertion of the strong "recti capitis antici," and for the depth of the median groove between them; the semicircular fossa in front of these processes is bounded by a well-developed basi-sphenoidal ridge (5), the curve of which is deeper than in *Chel. longiceps,* but shallower than in *Chel. breviceps.* In the *Chel. caouanna,* in which the basi-occipital tuberosities are better developed than in the *Chel. imbricata* or *Chel. mydas,* they are bounded anteriorly by an angular or chevron-shaped ridge of the basi-sphenoid. The exoccipitals (2) form the usual share of the trilobate occipital

condyle characteristic of the *Chelonia*. The paroccipitals (4) project backwards to a little beyond the posterior plane of the condyle, indicating an affinity to the *Trionycidæ*. The inferior surface of the part of the tympanic to which they unite is concave. The parietals (fig. 2, 7) form together a large semielliptic, almost flattened, platform, relatively broader than in *Chel. mydas,* not convex, as in *Chel. caouanna;* not indented by the mastoids, as in the *Chel. longiceps,* and not forming an angle between the frontals and postfrontals, as in the *Chel. breviceps.* The frontals (11) together form a pentagon, with the longest margin joining the parietals, the next in length converging to a point between the prefrontals, and the shortest borders joining the postfrontals. The postfrontals (12) and prefrontals (14) almost meet above the orbits, and exclude the frontals from entering into the formation of its superior border. The *Chel. mydas* comes nearest to the *Chel. cuneiceps* in this particular; whilst in the *Chel. imbricata* the frontals enter as largely into the formation of the upper border of the orbit as they do in the *Chel. breviceps, Chel. longiceps,* and *Chel. convexa.*

The precise form of the termination of the prefrontonasals, the maxillaries, and premaxillaries cannot be determined in the present specimen; fortunately, the fracture of the anterior extremity of the skull has not extended to that of the bony palate. If this be bounded by a transverse line behind, drawn across the anterior border of the temporal fossæ, the space included forms a right-angled triangle, and includes the whole of the posterior nostrils. In the *Chel. longiceps* the similarly defined space has the base shorter than the converging sides, and the posterior nasal aperture is behind the transverse line. The bony palate, also, of *Chel. cuneiceps,* instead of being pretty uniformly concave and even, as in *Chel. longiceps* and *Chel. caouanna,* is raised on each side between the middle line and the marginal alveolar plate into two convexities, as in *Chel. mydas* and *Chel. imbricata;* but the most prominent part of the palatal convexities (figs. 3 and 4, 21) is obtuse in *Chel. cuneiceps,* not sharp or angular, as in *Chel. mydas* and *Chel. imbricata.*

The palatal part of the vomer (13) forms the median longitudinal groove dividing the convexities, which are formed by the palatal processes of the maxillary bones. The small part of the alveolar border of the maxillary which is entire terminates in a sharp edge, extending about four and a half lines below the level of the palate.

The ridge of the palatines, which forms the anterior boundary of the posterior nostril, is not produced or bent below the level of the bony palate, as in *Chel. caouanna,* and as it is, although in a minor degree, in *Chel. mydas;* and there is not that concavity between it and the oblique palatal tuberosity which exists in the *Chel. mydas* and *Chel. imbricata.*

The pterygoids are more deeply (semicircularly) emarginate laterally than in any of the existing species of *Chelones,* and they are shorter in proportion to their breadth; they bound internally the lower apertures of the temporal fossæ, which are broader than they are long; in all the existing *Chelones* the opposite proportions prevail,

and in *Chel. imbricata* especially the homologous apertures are twice as long as they are broad. The pterygoids, in the *Chel. cuneiceps,* develope a sharp ridge along their median suture; and short but well-defined processes at their anterior and outer angles. The channel or concavity upon the under part of the diverging portion of the pterygoid conducts obliquely into the temporal fossæ in the *Chel. mydas;* in *Chel. cuneiceps* it leads directly forwards upon the under surface of the anterior part of the pterygoids exclusively, as in the *Chel. imbricata* and *Chel. caouanna.*

In the *Chel. mydas* the malar approaches the mastoid very closely, and sometimes touches it by the posterior angle, thus separating the squamosal from the postfrontal; the extent of the union between the squamosal and postfrontal is also shorter in the *Chel. caouanna* than in the *Chel. imbricata.* In the extent of that union (between 12 and 27) the *Chel. cuneiceps* resembles the *Chel. imbricata,* as do likewise the *Chel. breviceps* and *Chel. longiceps.* But the *Chel. cuneiceps* differs from all the recent species in the form of the squamosal (27), which is bent upon itself, forming a slightly curved linear eminence, where the lower and smoother part of the bone is bent, and, as it were, pressed inwards towards the tympanic (28), against which it abuts. This modification is natural, not the effect of accidental pressure upon the fossil. The lower border of the malar (26), which intervenes between the maxillary and squamosal, is sharp but convex, as in *Chel. caouanna,* not concave as in *Chel. mydas,* nor nearly straight, as in *Chel. imbricata.* But the concave curve of the inferior margin of the squamosal (27) most resembles that in *Chel. imbricata.* The antero-posterior extent of the mastoid (8) is less proportionally than in any of the recent *Chelones,* and it forms a smaller share of the upper border of the large meatus auditorius. The articular part of the tympanic descends below the squamosal further than in the recent turtles; and its articular surface is more convex at its outer half, and more concave at its inner half; *Chel. imbricata* makes the nearest approach to the fossil in this respect. In the *Chel. mydas* and *Chel. caouanna* the articular surface is nearly flat.

As the supracranial scutella have left unusually deep and well-marked impressions on this fossil skull, I have reserved their description, and the comparison of their different forms and proportions in the several fossil species, to this place.

Three scutella occupy the median line of the upper surface of the cranium in the present species of *Chelone,* which, from the absence of any impression along the frontal and sagittal sutures, appear to have been single and symmetrical. The anterior and smallest answers to the "frontal" scute (fig. 2, *fr*); the next in size and position to the "sincipital" scute (*sy*); the hindmost and largest answers to the "occipital" scute (*oc*), which is usually divided, and forms a pair in existing *Chelones.*

The frontal scute is long, narrow, hexagonal, broadest across the antero-lateral angles, from which the impressions extend outwards to the supraorbital margin, which divide the "fronto-nasal" scute from the "supraorbital" scute (*ob*).

The sincipital scute is bounded on each side by a sigmoid curve, and both before

and behind by an entering angle; it is broadest behind, and from the middle of the lateral border proceeds the transverse impression towards the back part of the orbit, which divides the "supraorbital" scute (*ob*) from the "parietal" scute (*pa*). The occipital scute is bounded laterally by straight lines, which slightly diverge as they extend backwards: there is no trace of an interoccipital scute. The parietal (*pa*) scute is the largest; impressions of five of its borders are preserved in the present fossil: the two exterior ones meet at an obtuse angle, a little above the middle of the *meatus auditorius externus;* the antero-external border uniting with the postorbital scute (*po*); the postero-external border with the external occipital scute (*eo*).

In the *Chelone breviceps* (Pl. 17*A*, fig. 2) the frontal scute is relatively larger than in the *Chelone cuneiceps,* and is nearly as broad as long. The sincipital scute is bounded laterally by two straight lines meeting at a very open angle, from which the transverse impression extends outwards between the supraorbital and parietal scutes. The straight lines bounding the sides of the occipital scute diverge from each other as they extend backwards more than they do in the *Chelone cuneiceps.*

In the *Chelone longiceps* (Pl. 12) a still more different pattern of the supracranial scutation is presented. The occipital scutes (*oc*) are separated by an intervening interoccipital scute (*io*). The lateral borders of the sincipital scute are each bounded by three lines and two angles; the antero-lateral and postero-lateral angles being curved with the concavity outwards; and the transverse impression dividing the supraorbital scute (*ob*) from the parietal scute (*pa*), proceeds from the middle of the intervening straight border of the parietal. The frontal scute (*fr*) is long and narrow, broadest behind, with its lateral borders gradually converging to a point anteriorly; the impression dividing the supraorbital (*ob*) from the frontonasal scute (*fn*) proceeds from the middle of that lateral border. Neither the division between the frontal and sincipital, nor that between the sincipital and interoccipital scutes are well marked.

The *Chelone convexa* (Pl. 24, fig. 4), like the *Chelone longiceps,* has an interoccipital scute (*io*), and the sincipital scute (*sy*) has its sides bounded by three lines, of which the posterior one is curved with its concavity towards the occipital scute (*oc*), and so directed as to appear to form part of the posterior rather than the lateral border; the other two lines completing the lateral border and converging forwards, are divided or defined by a slight angle, from which the transverse impression proceeds outwards, which divides the supraorbital (*ob*) from the parietal (*pa*) scutes. The frontal scute (*fr*) is a small hexagon, relatively wider than in *Chel. longiceps* or *Chel. cuneiceps.* The impression dividing the supraorbital (*ob*) from the frontonasal (*fn*) scutes proceeds from the angle between the lateral and anterior sides of the frontal scute.

The *Chelone planimentum* (Pl. 18) is peculiar, and differs from all the foregoing species by the forward extension of the occipital scutes which join the supraorbital scutes, and thus divide the sincipital scute (*sy*) from the parietal scute (*pa*); the sincipital scute

is correspondingly encroached upon, as it were, and narrowed, its broadest part being nearer the anterior end, at the angle between its two straight lateral borders, from which angle the impression extends outwards that divides the occipital from the supraorbital scute. The frontal scute (*fr*) is small and narrow, and the large supraorbital scutes meet in front of it at the middle line. They appear to be divided from the orbits by the encroachment of palpebral scutes (*pl*) upon the supraorbitary border. There appears to have been an interoccipital scute in the *Chel. planimentum*, as in the *Chel. longiceps* and *Chel. convexa*.

Amongst existing *Chelones* the interoccipital scute is constant only in the *Chel. caouanna*—the loggerhead of Catesby and Brown; but the sincipital scute in this species is vastly larger in proportion than in any of the fossils above described; and it is further distinguished by the peculiar division of the supraorbital and parietal scutes.

In the hawks-bill turtle (*Chel. imbricata*), the supracranial scutes leave as well-marked indentations upon the bones of the cranium as are seen in most of the fossil turtles, but the supraorbital scute is proportionably larger than in any of these, and the proportions and forms of all the other scutes are different. There are, also, two nasal scutes divided by a transverse groove from the frontonasals, which groove I have not yet met with in the corresponding part of any of the fossil Chelonian crania.

The skull of the *Chelone cuneiceps*, here described, is from the London clay of Sheppy.

Chelone subcarinata. *Bell.* Plate 10.

The resemblance of this species to *Chelone subcristata* (p. 24, Pl. 15) is so considerable, that it has not been without some hesitation that I have ventured to describe it as distinct. There are, however, certain characters by which it may be distinguished, and those of sufficient importance to be considered as specific. On comparing it with recent species, and even with most of the fossil ones from the same locality, there is a remarkable evenness in the arch of the carapace, which, with the exception of a slight carina on some of the posterior neural plates, to be hereafter mentioned, forms nearly a perfect arc of a circle, from the extremity of the costal plate of the one side to that of the other, without that flattening of the side which is seen in most other species.

The nuchal plate (Pl. 10, fig. 1, *ch*) has the posterior margin arched, and there is a short median process which goes to join the first neural plate (*s*1), in which respect it agrees with *Chel. longiceps* and with *Chel. subcristata*. This process is emarginate, to receive a slight triangular projection of the anterior margin of that plate. The first neural plate (*s*1) forms a parallelogram, the sides not being interrupted by any costal suture; the posterior suture of the first costal plate (*pl*1) extending to the second neural plate (*s*2). In this circumstance it differs from *Chel. subcristata, longiceps,* and *convexa,* and agrees with *Chel. breviceps*. This, however, may possibly be a variable character here, as

it is in *Chel. longiceps;* in one specimen of which, now before us, the articulation of the first costal plate was with the anterior part of the second, instead of the posterior part of the first, neural plate; in other words, the first neural plate was the isolated one instead of the second. The remaining neural plates are hexagonal, becoming almost regularly shorter to the eighth; the lateral angles meeting the costal sutures being nearly at the same distance from the anterior margin in each, and in no one at all approaching a regular equilateral hexagon, as in many of the neural plates in *Chel. breviceps.* The first three, and the anterior half of the fourth neural plates are flat; but on the posterior half of the fourth commences a low carina, which becomes highest on the posterior half of the sixth (*s*6), and anterior half of the seventh (*s*7). It thus differs from *Chel. subcristata,* in which there is a distinct. short, sharp, longitudinal crest (*s*1) on the fifth and seventh neural plates, " and a similar crest is developed on the contiguous ends of the second and third neural plates." The ninth and tenth neural plates are wanting in the only specimen I have seen of the *Chel. subcarinata.*

The first costal plate is flat (*pl*1), but the remaining ones, to the seventh inclusive, are slightly hollowed along the middle, being raised towards the anterior and posterior margins, where they are articulated to the contiguous ones. The whole surface of the bones of the carapace is less smooth than in most other fossil species, and conspicuously less so than in *Chel. subcristata.*

In describing the forms of the vertebral scutes, (*v*1—*v*4), and of the costal ones as depending upon them, it is necessary, in order to arrive at any satisfactory comparison between these parts in different species, to bear in mind that a great change takes place in their outline during the growth of the animal; and that a vertebral scute, which, in a younger individual, has the middle of its outer margin exceedingly extended, so as to form a very acute angle, where the lateral margin of the costal scute joins it, and thus rendering it twice as broad as it is long, may in more advanced age have that angle very open, and having increased greatly in length, and scarcely at all in breadth from angle to angle, the length becomes greater than the breadth. Allowing, however, for this fact, there are doubtless considerable variations in this respect according to the different species, which are permanent and well marked. The first vertebral scute (*v*1) in the present species is quadrilateral, broader anteriorly; the second and third (*v*2, *v*3) hexagonal, with the outer margins slightly waved, somewhat broader in the middle at the angles than at the anterior and posterior margins, the comparative breadth at that part being rather greater than in the corresponding scutes of *Chel. subcristata,* and much less so than in *Chel. convexa, Chel. breviceps,* or *Chel. longiceps.* The fourth vertebral scute (*v*4) is also hexagonal, but the portion posterior to the lateral angles is narrowed and produced backwards. The last of the series is fan-shaped. The outline of the costal scutes follows of course that of the vertebral ones.

The plastron, in the specimen from which this description is taken (Pl. 10, fig. 2), is more perfect than in that of almost any other fossil Chelonian I have seen. It

agrees in its general form with that of *Chel. subcristata,* but is less extensive, as regards its bony surface, than in *Chel. longiceps* or even than in *Chel. breviceps.* The entosternal bone (*s*) is somewhat wedge-shaped, with the anterior margin triangular, and a short winged process on each side of the anterior third of the bone extending outwards and backwards. The posterior extremity of the bone, and the winged processes are dentate. The episternals (*es*) are aliform, tending backwards and outwards, and inclosing between them the head of the entosternal (*s*), and the anterior processes of the hyosternal bones (*hs*). The latter have the anterior processes extending forwards on each side of the entosternal, approximating at their extremity the aliform processes of that bone. The median or internal processes nearly meet on the median line, and the dentations are deep but slender; each hyposternal (*ps*) unites similarly with its fellow, and the posterior process extends backwards, in a long, narrow, triangular piece, uniting with the xiphisternal (*xs*), which latter forms a very elongated rhomb, the breadth of which is scarcely one fourth of its length, which in the present specimen is no less than two inches six lines. This form, with the elongation and narrowness of the posterior process of the hyposternal, gives to the hinder portion of the plastron in this species a narrower and more elongated outline than we find in almost any other; an approach to which is, however, indicated in the imperfect specimen of *Chel. subcristata* figured in Plate 15.

The external notch, between the external process of the hyosternal and hyposternal, is deep and rounded. The central interspace is nearly quadrate, and about half as long again as it is broad.

	Inches.	Lines.
Length of the carapace as far as it is preserved	9	5
Breadth of ditto from the extremity of the third costal plate on one side to that on the other	7	4
Ditto, following the convexity of the carapace	9	3
Length of plastron from the anterior margin of the episternal to the extremity of the xiphisternal	8	4
Breadth of ditto across the hyosternals	7	0

The only specimen of this species which I have seen is from Sheppy, and is in the fine collection of J. S. Bowerbank, Esq., F.R.S.

T. B.

SUPPLEMENTAL REMARKS

ON THE

TURTLES FROM THE LONDON CLAY AT HARWICH.

In the progress of the works now carried on in a part of the Harwich cliffs, with a view to the acquisition of the remains of the animal tissues and bone-earth which form the nodules that are ground up and used as manure, many remains of the Chelonian reptiles which formerly frequented the seas from which those Eocene tertiary strata have been deposited have been discovered. Mr. Colchester, of Little Oakley, Essex, who carries on large works of this kind for the "Fossil Guano," as it is termed, has transmitted to me a number of the nodules in question. The most intelligible and instructive of these I have marked from 1 to 10 consecutively, and shall notice them here in the same order.

No. 1. *Chelone planimentum.* This is the half of an oval nodule of petrified clay, 20 inches in length, by 17 inches in breadth, exposing an irregular group of disarticulated bones of the carapace and other parts of the skeleton. The species is determined by a fragment of one of the costal plates with the connate rib. The plate measures $2\frac{1}{2}$ inches in breadth, the rib 8 lines, and forms the usual partial prominence from the even surface of the under part of the costal plate. Almost the whole of the very broad but short nuchal plate is recognisable: it measures 6 inches in transverse diameter, and only $1\frac{1}{2}$ inch in antero-posterior diameter. Part of the hyosternal bones, and the impression of the humerus are recognisable.

No. 2 is the half of a nodule, 20 inches in length and 17 inches in breadth, exposing part of the plastron, and some other bones of the skeleton of the *Chel. planimentum.* It shows well the natural form of the under and outer part of the hyposternal bone, which is much more deeply excavated than in the *Chel. crassicostata;* the lower portion of the bone is narrower in proportion to its length, and the xiphisternals are also in proportion longer and narrower than in that species.

No. 3. *Chelone planimentum.* The half of an oval nodule, 17 inches in length and 13 inches in breadth. The fractured side exposing a cast of the inner surface of the carapace, which measures in length from the nuchal to the tenth neural plate inclusive $13\frac{1}{2}$ inches; and in breadth, across the third pair of costal plates from one end of the projecting rib to that of the opposite side, 11 inches. The anterior contour of the

carapace is well shown in this nodule, the marginal plates which join the nuchal plate being preserved. The free extremity of the rib attached to the third costal plate projects 1 inch 9 lines from that plate, and measures 7 lines in breadth, where it becomes free ; the breadth of the plate being nearly 2 inches. The transverse curve of the carapace is shown by this specimen to be much less than in the *Chel. crassicostata*.

No. 4. *Chel. planimentum.* The nodule shows partly a cast of the outer surface of the carapace, with part of the carapace itself. The outer angles of the third and fourth vertebral scutes are here seen with the inner angle of the third costal scute. The outer angles of the vertebral scutes are more prominent than in *Chel. declivis*, *Chel. subcristata*, *Chel. subcarinata*, *Chel. convexa*, or *Chel. longiceps ;* they resemble most those in *Chel. breviceps.* The breadth of the third costal scute is 4 inches. The characteristic angular ridge, formed by the narrow connate rib, where it projects from the lower surface of the costal plate, is well shown in this specimen.

No. 5. A nodule showing a cast of the under surface of the carapace seen from above, apparently of the *Chel. planimentum.*

No. 6. A nodule, 10 inches long by 9 inches broad, showing a still more imperfect cast of the under surface of the carapace, of apparently a younger specimen of the *Chel. planimentum.*

No. 7. A fragment of a nodule showing the outer dentated extremity of the left hyosternal of the *Chel. planimentum.*

No. 8. A portion of a nodule, with part of the carapace of the *Chel. planimentum*, showing the second to the seventh neural plates inclusive, and portions of the second to the seventh costal plates of the right side, with more or less of their bony substance broken away, exposing their coarse fibrous character, the fibres diverging on each side from the subjacent rib, as they extend obliquely towards the periphery of the carapace. The third neural plate is 2 inches 3 lines in length and 1 inch in breadth ; it is crossed at its middle part by a moderately broad and deep channel, indicating the junction of the second with the third vertebral scute. The third neural plate is hexagonal ; the two shortest sides being formed by the truncation of the contiguous angles of the second costal plates bending down a little to articulate with them. The fourth neural plate is 2 inches 6 lines in length, and 1 inch 4 lines across the broadest part. The anterior surface is concave, the posterior convex ; the two longest sides converge towards the posterior surface, and are straight. The fifth and sixth neural plates progressively decrease in length, without a proportionate decrease in breadth. The breadth of the fourth costal plate is 2 inches 3 lines at its peripheral extremity ; its length is 6 inches ; the rib projects 2 inches beyond it. The upper

surface of the neural and costal plates is so minutely fibrous or striated as to seem at first sight almost smooth. The upper surface of the costal plate seems naturally to be slightly concave in the direction of the axis of the carapace, but not so much as in *Chel. crassicostata*, and the rib is much bent lengthwise.

No. 9. *Chelone crassicostata* (Pl. 22*A*). This instructive specimen is contained in a subspherical nodule, 13 inches long by 12 inches broad, exposing a large proportion of the outer surface of the carapace, with more than one half of the circle formed by the marginal plates (*m7—py*). The carapace has been fractured, and the ribs of the left side dislocated and pressed down below those of the right. The third (*pl*3) to the eighth (*pl*8) costal plates inclusive are present on the left side; the fifth to the eighth on the right side, and the neural plates from the fourth to the pygal plate (*py*) inclusive. The fourth, fifth, and sixth neural plates are hexagonal, with the anterolateral sides shortest, and chiefly remarkable for their great breadth in proportion to their length. The seventh and eighth are small, and more regularly hexagonal. The ninth is a broad subcrescentic plate, with the broad concave side backwards, and the space between this and the pygal plate is filled up by an equally broad but pentagonal neural plate. The length of the ninth and tenth neural plates, with the pygal plate inclusive, is 2 inches 9 lines. The pygal plate is subquadrangular and broadest behind, where it is slightly emarginate. The length of the fourth to the eighth neural plate inclusive is 3 inches 8 lines. The upper surface of the bones of the carapace is almost smooth. That of the costal plates is chiefly remarkable for its concavity transversely, or in the direction of the axis of the carapace, which is to a greater degree than in the *Chel. subcristata* or *Chel. longiceps;* the lines of the sutural union of these plates with each other forming so many ridges across the sides of the carapace. The degree of curvature or convexity in the direction of the length of the costal plate is much greater than in the *Chel. planimentum.* The length of the third costal plate is $3\frac{1}{2}$ inches, its breadth at the outer extremity, 1 inch 4 lines; the breadth of the rib where it projects beyond it is 9 lines. The margin of the plate attached to that rib is 1 inch 4 lines in length, and 8 inches in breadth. The margin of the plates gradually increases in breadth towards the posterior part of the carapace, the one joining the pygal plate being 1 inch 2 lines in breadth. The general form of the carapace of the *Chel. crassicostata* is shown by the present specimen to have been that of a full oval, with a gently festooned border, not pointed behind.

No. 10. *Chelone crassicostata* (Pl. 22*B*.) A still more remarkable example of this species was kindly transmitted to me by the Rev. S. N. Bull, M.A., of Harwich, of which a figure is given in Pl. 22*B*. When it first came into my hands it was an unpromising semioval nodule, 10 inches in length by 7 inches in breadth, presenting on its convex surface portions of the posterior neural and costal plates, with their external surface entire; but no trace of plastron on the flattened side. The degree of convexity formed by the costal plates equalled that of the

most dome-shaped tortoise. The flatter surface of the nodule was slightly convex, which I thought might arise from a layer of petrified clay adhering to the plastron. A portion of the cranium was indicated at the produced angle of the nodule. To ascertain whether this remarkable degree of convexity of the carapace, both lengthwise and transversely, was natural, I had the matrix carefully removed, with the permission of the owner of the specimen, and the same was done on the opposite side, with a view to expose the plastron. Instead of finding a plane plastron where it was expected, in its natural horizontal position, it was found to have been crushed inwards, as represented in fig. 2, by the pressure of a hard petrified mass as big as a paving-stone, which had been forced in upon this part of the body of the turtle whilst in a decomposing state; and when finally lodged in the clay, the carapace and plastron, as they became dislocated, had become more or less moulded upon it; and thus was produced the convexity which originally attracted my attention. In the breadth of the connate rib, as compared with that of the costal plate, in the extent of the free extremity of the rib, in the degree of concavity of the upper surface of the costal plate and the curvature lengthwise, the distinctive characters of the *Chel. crassicostata* are well shown. The same characters are likewise presented by the parts of the plastron, as in the breadth of the xiphisternals (*xs*), the curvature of the hyosternal (*hs*), and the form of the coracoid. The two scapulæ, with the connate acromial clavicles, are preserved, with the head of one of the humeri. A part of the basis cranii, showing the broad diverging pterygoid, with their characteristically-channeled inferior surface, is shown in fig. 2; these grooves are not so deep, however, as in *Chel. longiceps*, but are more like those in *Chel. cuneiceps*.

I beg to record my obligations to Mr. Bowerbank for the suggestion, and to Mr. Bull for his ready response to it, to which I owe the opportunity of examining this specimen of the thick-ribbed turtle of the Harwich cliffs.

A fossil mandible of a Chelonian, in the collection of the Marchioness of Hastings (figured, of the natural size, in Pl. 33, figs. 1 and 2), most resembles that part in the genus *Chelone* by its general form and proportions, and especially by the configuration of the biting and grinding surface of the jaw (fig. 2). The symphysis is confluent; convex in both directions below; longer than in the *Chel. mydas* and the *Chel. breviceps* of Sheppy (Pl. 17*A*, fig. 3, 32); but not so long as in the turtles from Harwich (Pl. 18, fig. 1, and Pl. 20, fig. 3) and Bracklesham, or as in the *Chelone longiceps* of Sheppy. The rami diverge more from each other than in the lower jaw of the *Chel. convexa* (Pl. 14, fig. 3) of Sheppy.

A ridge, commencing at the fore part of the upper surface of the symphysis, passes backwards, and divides the two ridges, diverging and circumscribing with the outer sharp margins of the jaw an elliptical concave space on each side; the space between the diverging ridges is raised and rough: this part has been fractured. In the *Trionyx*, of which genus so many fine examples have been met with at Hordwell, the upper part

of the symphysis presents an uniform concavity; and this part of the jaw is narrower and more produced. I have not yet seen the mandible of any Emydian or land-tortoise resembling the present fossil so closely as some of the marine species above cited. A large species of *Emys* has, however, left its remains in the same deposits at Hordwell as the *Trionyces* next to be described.

A retrospect of the facts above detailed, relative to the fossil Chelonians of the genus *Chelone*, or marine family of the order, leads to conclusions of much greater interest than the previous opinions respecting the Chelonites of the London clay could have suggested. Whilst these fossils were supposed to have belonged to a fresh-water genus, the difference between the present fauna and that of the Eocene period, in reference to the Chelonian order, was not very great; since the *Emys* (*Cistuda*) *Europæa* still abounds on the continent after which it is named, and lives long in our own island in suitable localities. But the case assumes a very different aspect when we come to the conviction that the majority of the Eocene Chelonites belong to the true marine genus *Chelone;* and that the number of species of these extinct turtles already obtained from so limited a space as the Isle of Sheppy, exceeds that of the species of *Chelone* now known to exist throughout the globe.

Notwithstanding the assiduous search of naturalists, and the attractions to the commercial voyager which the shell and the flesh of the turtles offer, all the tropical seas of the world have hitherto yielded no more than five* well-defined species of *Chelone;* and of these only two, as the *Chel. mydas* and *Chel. caouanna*, are known to frequent the same locality.

It is obvious, therefore, that the ancient ocean of the Eocene epoch was much less sparingly inhabited by turtles; and that these presented a greater variety of specific modifications than are known in the seas of the warmer latitudes of the present day.

The indications which the English Eocene turtles, in conjunction with other organic remains from the same formation, afford of the warmer climate of the latitude in which they lived, as compared with that which prevails there in the present day, accord with those which all the organic remains of the oldest tertiary deposits have hitherto yielded in reference to this interesting point.

That abundance of food must have been produced under such influences cannot, of course, be doubted; and we may infer that, to some of the extinct species, which, like the *Chel. longiceps* and *Chel. planimentum*, exhibit either a form of head well adapted for penetrating the soil, or with modifications that indicate an affinity to the *Trionyces*, was assigned the task of checking the undue increase of the now extinct crocodiles and gavials of the same epoch and locality, by devouring their eggs or their young; becoming probably, in return, themselves an occasional prey to the older individuals of the same carnivorous Saurians.

* Mr. Gray, for example, includes the *Chelone virgata* and *Chelone maculosa* of Dumeril and Bibron as varieties of the *Chelone mydas*.

Family—Fluvialia.

Genus—Trionyx.

The Chelonian Reptiles called "Soft Tortoises," forming the genus *Trionyx* of Geoffroy St. Hilaire,* and the family *Fluvialia* seu *Potamites* of MM. Duméril and Bibron,† resemble those of the genus *Chelone* (family *Marina* seu *Thalassites*, Dum. and Bibr.) in the extremity of the vertebral rib, or pleurapophysis, projecting freely from below the end of the connate costal plate,‡ and in having the plastron incompletely ossified; but they are characterised by the still more incomplete ossification of the margin of the carapace, which retains much of its primitive soft, cartilaginous state; and they are further distinguished by the reduced number of the toes—three on each foot—which are armed with claws, the other two toes serving to support a swimming web; the name of the genus has reference to this peculiarity.

The head is depressed, elongated, and, in the recent animal, the nostrils are prolonged into a short tube, terminated by a small fleshy appendage like an elephant's proboscis. The outer surface of the dermal bones of the carapace, and of the corresponding parts of the plastron, is variously sculptured, usually by sinuous grooves and rugosities, as if wormeaten; and to such a degree in some species, as to give the parts a tuberculate character. The cuticle is soft and flexible, not developed into scutes; and there are accordingly no impressions like those that indicate the presence of the "tortoise-shell" plates in the skeleton of the existing turtles and in the petrified plastrons and carapaces of the extinct species of the marine family.

"Hitherto," write the meritorious authors of the elaborate 'Erpétologie Générale,' one has not observed any species of this family (*Potamites*) in our European rivers; all those which have been described, and of which the habitat is known, have come from the streams, rivers, or great fresh-water lakes of the warmer regions of the globe." (Tom. ii, p. 469.) The beautifully-preserved evidences of the species about to be described, which have chiefly been obtained by the Marchioness of Hastings from one limited locality, attest the abundance of the *Trionyces* in the fresh-waters of our latitudes during the Eocene period of geology.

The characters by which MM. Wagler and Duméril have divided the species of

* Annales du Muséum d'Histoire Naturelle, tom. xiv.

† Erpétologie Générale, 8vo, tom. ii, p. 461.

‡ This character is well exemplified in the Marchioness of Hastings's unique and beautiful specimen of the *Trionyx rivosus*, Pl. 29.

Trionyx, Geoffr., into two genera, are not such as can be decisively recognised in the fossil carapace. A difference of convexity of that part by which the "*Cryptopodes*" are said to differ from the *Gymnopodes,* is not one that the comparative anatomist and palæontologist would recognise as valid for the distinction proposed.

Upon the whole, the fossil specimens in which that character can be compared, agree rather with the *Gymnopodes* of Dum. and Bibr., but with a range of diversity which is exemplified by Pls. 5 and 32. So much of the plastron as I have been able to compare, agrees likewise with the bones of that part in the *Gymnopodes*, but, in the absence of more certain characters, and with doubts as to the necessity or desirableness of the subdivision proposed for the recent species, I shall retain the name *Trionyx* for all the fossils that manifest, in their petrified remains, the characters of the Geoffroyan genus.

In the second part of my 'Report on British Fossil Reptiles' I showed that certain fossils of the Wealden formation and of the Caithness slate (new red sandstone) had been referred erroneously to the genus *Trionyx*, and that the only unequivocal remains of that genus which had been seen by me at that period (1841) were from Eocene deposits at Sheppy, Bracklesham, and the Isle of Wight, in which latter locality they were associated, as in the Paris basin, with remains of the *Anoplotherium* and *Palæotherium*.

I have since had the opportunity of examining fossil specimens of *Trionyx* from other localities, but always, however, from formations of the Eocene period, and I shall commence their description with one of the most perfect and beautiful examples of these Chelonites, which was obtained by the Marchioness of Hastings from the Eocene sand of the Hordwell Cliff, Hants.

TRIONYX HENRICI. *Owen.* Plate 6.

Report of the Seventeenth Meeting of the British Association, 1847, p. 65.

Although the characteristics of the genus are readily recognisable in fossil fragments of the carapace and plastron, from their comparative flatness and the sculpturing of the outer surface, the species of *Trionyx* are with difficulty determinable, if at all, from such specimens; and it is usually necessary to have a considerable part of the carapace, in order to ascertain its composition, contour, and degree of convexity. Some species, indeed, e. g. *Trionyx rivosus* (Pl. 29), *Trionyx marginatus* (Pl. 30), together with the *Trionyx spinosus** and *Trionyx sulcatus* of Kutorga, would seem to be characterised by particular patterns of the irregular surface of the bones of the carapace, which character, therefore, a fragment may suffice to manifest; but this is not the case with the ordinary rugose and vermiculate species. Cuvier accordingly

* This is quite a distinct species from the *Trionyx spiniferus* of Lesueur.

admits, with respect to the portions of *Trionyx* found abundantly in the gypsum of the environs of Paris, associated with the Palæotheres, Anoplotheres, and other extinct animals of the Eocene epoch, that he could find nothing in those fragments to authorize him to fix their specific characters.* The compilers of the labours of practical palæontologists have, as usual, been affected by no such scruples, and have not hesitated to assume a knowledge, which Cuvier did not feel himself entitled to claim, viz. that of the fact of the specific distinction of the *Trionyx* of the Montmartre quarries: but I do not find that they have added anything to its history except the name of *Tri. Parisiensis.* It is probable, from the analogy of our own Eocene deposits, that more than one species of *Trionyx* may have left its remains in the Parisian localities of the corresponding geological formation.

The fossil remains of *Trionyx* from the tertiary deposits of the Gironde,† Lot-et-Garonne,‡ Montpellier, and Avary, were not sufficiently characteristic to permit the great anatomist and founder of Palæontology to infer more than the existence of the particular genus of fresh-water Chelonia in question in those formations. The only specimen of fossil *Trionyx* in which Cuvier recognised characters distinguishing it from the known existing species, is that which M. Bourdet first described§ under the name of *Trionyx Maunoir*, from the Eocene quarries at Aix. Cuvier has given reduced views of a large proportion of its carapace and half its plastron in the 'Ossemens Fossiles,' tom. v, pt. ii, Pl. XV, figs. 1 and 2. This description and the figure of the carapace serve to elucidate by comparison the characters of the more perfect specimen of *Trionyx* here described from the Eocene of Hordwell.

In the first place, the contour and proportions of the entire carapace of the *Tri. Henrici* differ from those of the *Tri. Maunoir.* The carapace of the *Tri. Henrici* (Pl. 6), which is formed, as usual, by the neural plates (*s*1, *s*2, &c.) and eight pairs of costal plates (*pl*1—8), measures 10 inches 8 lines in length, and 11 inches 2 lines in breadth, in a straight line across the third (*pl*3) costal plate, where it is widest. In *Tri. Maunoir*, the neural plates (plaques vertébrales) rise a little above the plane of the carapace, as in the *Tri. ferox* (*Tri. carinatus*, Geoffr.‖): in the *Tri. Henrici* there is no trace of this carinate structure; the neural plates are flat, and on a level with the broad costal plates articulated with them; in which characters it resembles the *Tri. gangeticus*, Cuv., and *Tri. javanicus*, Cuv.

The first costal plate (*pl*1) is broader than it is long in *Tri. Maunoir;* in *Tri. Henrici* its breadth is little more than half its length, and decreases as it recedes from

* "Mais je n'ai rien trouvé dans ses débris qui m'autorisât à en fixer les caractères spécifiques." (Ossemens Fossiles, tom. v, pt. ii, p. 223.)

† Cuvier, tom. cit., pp. 225, 227.

‡ The skull of the *Trionyx* from this locality showed a slightly different profile from that of any of the existing species.

§ Bulletin de la Société Philomathique, 1821.

‖ Annales du Muséum, tom. xiv, pl. 4, 1809.

the neural plate. The second costal plate, on the contrary, is broader at its lateral than at its mesial end in *Tri. Henrici*, whilst its breadth is equal at both ends in the figure given by Cuvier of the *Tri. Maunoir*. The thickness of the costal plates, in proportion to their breadth, may be known by reference to Pl. 31, figs. 4 and 5; and the degree of projection of the connate rib from the inner surface of the costal plate by figure 6; the *Tri. Henrici* closely agreeing with *Tri. marginatus* in these respects. The peripheral border of the carapace is not grooved in this species, as in the *Tri. circumsulcatus*, fig. 3.

The degree of transverse convexity of the carapace of the *Tri. Henrici* is the same as that of the *Tri. Ægyptiacus*, and as that attributed to the *Tri. Maunoir.**

The nuchal plate is wanting in Lady Hastings's specimen; the one which is figured in Pl. 6, fig. 3, is from the same locality at Hordwell, but does not belong to the carapace, fig. 1, although it has probably belonged to one of the same species, from the contour of its hinder border.

The first neural plate ($s1$) does not project beyond the adjoining anterior borders of the first costal plates ($pl1$) as it does in *Tri. subplanus*, *Tri. ferox*, and *Tri. javanicus;* nor do those borders, as they recede from the neural plate, curve forwards beyond it, as in *Tri. javanicus*† and *Tri. coromandelicus.*‡

The anterior border of *Tri. Henrici* is slightly concave and gently undulated, as in the *Tri. Ægyptiacus*, and is also rough and sutural, showing that the anterior azygos or nuchal plate ("pièce impaire," Cuv.) had been immediately articulated with it, as it is in *Tri. Ægyptiacus.*§

The fossil specimen of the nuchal plate, figured in Pl. 6, fig. 3, shows, by the sutural structure of its posterior border, that it articulated with the anterior sutural border of the carapace to which it belonged, and which, as already remarked, belonged probably to the species *Tri. Henrici*, though not to the individual the carapace of which is figured in Pl. 6, fig. 1.

The neural plate ($n1$) is longer in proportion to its breadth, and the corresponding costal plates ($pl1$) are narrower at their extremities than in *Tri. Ægyptiacus*. The second costal plates ($n2$) are broader at their extremities than in *Tri. Ægyptiacus;* they resemble those in *Tri. subplanus.*‖

The first four neural plates in *Tri. Henrici* slightly expand posteriorly, and have their posterior angles cut off; the fifth ($n5$) is a narrow plate with entire angles; the sixth ($n6$) is expanded anteriorly, and has its anterior angles cut off; the seventh ($n7$) has also its anterior angles cut off, but is rounded behind, and, as it were, obliterated

* "Sa convexité transversale est telle, que la flèche de l'arc est moindre du cinquième de la corde." (Cuvier, Ossemens Fossiles, tom. v, pt. 2, p. 223.)

† Annales du Muséum, tom. xiv, pl. 3, *A*.

‡ Ibid., pl. 5, fig. 1.

§ Ibid., pl. 2, A, *a*.

‖ Ibid., pl. 5, fig. 2.

by the extension of ossification from the costal plates into the dermal cartilage above the neural spines. The eighth neural plate is wholly obliterated or superseded by a similar encroachment and union of the eighth pair of costal plates (*pl*8). Almost the same modification is represented by Geoffroy in the carapace of the *Tri. Ægyptiacus*;* but the general proportions of the carapace of the *Tri. Henrici* are more like those in the *Tri. subplanus,* in which the eighth neural plate exists in the interspace of the eighth pair of costal plates, as it does likewise in *Tri. Maunoir.*

All the exterior surface of the expanded parts of the neural spines and ribs is roughened or sculptured with a moderately fine vermicular pattern, the undulatory grooves having a tendency to a concentric arrangement at the peripheral surface of the carapace, and in general passing uninterruptedly from one costal plate to another: the pattern is effaced from about one third of an inch of the border of the carapace, which presents a surface like that of a coarsely-woven cloth. The extreme border is rather suddenly bevelled or rounded off from above downwards, and is thinner than the border of the costal plates that articulates with the neural plates. The natural extent of the ordinary narrow extremities of the ribs cannot be determined from the present specimen of the *Tri. Henrici;* they form the usual slight relief along the middle of the smooth under surface of the connate costal plates; and do not subside at any part of their course to the level of the under or inner surface of the plate.

Plate 6, fig. 1, shows the upper surface of the carapace of the *Tri. Henrici,* half the natural size.

Fig. 2, in outline below, gives the curve and degree of transverse convexity across the middle of the carapace.

Fig. 3, the nuchal plate of apparently the same species of *Trionyx*, half the natural size.

These specimens were discovered by the Marchioness of Hastings in the Eocene sand at Hordwell, and are preserved in her ladyship's Museum at Efford House, near Lymington, Hampshire. The species is dedicated to her ladyship's husband, Captain Henry, R.N.

In the figure of the carapace of the *Trionyx* (*Tri. subplanus*) in Cuvier's pl. xiii, fig. 5, 'Ossemens Fossiles,' tom. v, pt. ii, the costal plates do not bear the same numbers as the corresponding neural plates; the anterior costal plate is marked *a*1, whilst the corresponding neural plate is *b*2; the rib or pleurapophysis of the first dorsal vertebra, which is marked *c*1, is short, and is applied to the under and fore part of the second rib which supports the first costal plate. In Pl. 6, the dermal ossifications of the carapace bear the same letters and numbers as the homologous parts in the previous plates, and in the woodcut, fig. 1, p. 3.

* Ibid., pl. 2, *A*.

TRIONYX BARBARÆ. *Owen.* Plate 5.

This species, like the *Trionyx Henrici*, is most satisfactorily and beautifully represented by an entire carapace in the collection of the Marchioness of Hastings, to whose indefatigable researches in the locality of the Eocene sand at Hordwell Cliff, its discovery is due, and by whose skill, tact, and patience it has been faithfully restored from its original fragmentary state.

The carapace is more slender in proportion to its length, and deeper or more convex in proportion to its breadth, than in the *Tri. Henrici.* In this species, as is shown in Pl. 6, the breadth is greatest towards the fore part of the trunk; in the *Tri. Barbaræ* this is the narrower part, and increases in breadth towards the middle of the carapace (*pl*4).

The antero-posterior diameter or length of the nuchal plate is greater in proportion to its transverse diameter or breadth, and the arched ridge on its inner surface is less strongly developed than in *Tri. Henrici.* On the outer surface the smooth anterior border, where the plate would seem as if cut away obliquely to an edge, is more extensive in comparison with the rough, worm-eaten surface in the *Tri. Henrici* (Pl. 6, fig. 3), or those in the nuchal plate of *Tri. incrassatus* (Pl. 27, fig. 1, *ch*). The median part of the anterior border is more deeply excavated, and the lateral borders less deeply dentated in the *Tri. Barbaræ.*

The whole of the posterior border of the nuchal plate is thick, sutural, and is articulated to the first neural plate and the anterior costal plates (*pl*1); the middle part extending backwards to unite with the neural plate, by which also *Tri. Barbaræ* differs from *Tri. Henrici.*

The first neural plate is shorter and broader in proportion to the length of the costal plates than in the *Tri. Henrici*, but presents a similar shape, the sides being parallel, and the posterior angles truncate; in the three succeeding neural plates the sides converge towards the anterior end, but the posterior angles continue to be cut off. The fifth neural plate is oblong and quadrangular, as in *Tri. Henrici* (Pl. 6). In the sixth neural plate the fore part is the broadest, and its angles are truncate; the seventh is a subtriangular and not fully-developed plate; the corresponding pair of costal plates meeting behind it. The eighth pair of costal plates (*pl*8) similarly supersede and take the place of *s*8, by meeting and joining at the middle line, but the left is the broadest, not the right.

The first costal plate (*pl*1) is longer in proportion to its breadth (or antero-posterior diameter), which is also more equally preserved throughout its length than in the *Tri. Henrici*, and the connate smooth rib is less prominent on its under surface. The inner and anterior angles of this surface do not show the depression formed by the head of the vertical scapula, which is present in that part of the stronger *Tri. Henrici.*

A well-marked distinctive character is also afforded by the seventh costal plate (*pl7*), from which the free end of the connate rib projects at the anterior angle of the dilated end in *Tri. Barbaræ,* and the free border of that end describes a straight line transverse to the axis of the carapace.

The free borders of the eighth pair of costal plates are on the same transverse line, and the posterior part of the carapace is censequently truncate and straight.

The lateral margin of the carapace is more gradually bevelled down, and to a less obtuse edge than in the *Tri. Henrici.*

The length of the carapace of the *Tri. Barbaræ,* from the fore part of the first neural plate to the hind border, is nine inches and a half; the greatest breadth of the carapace, in a straight line across the fourth pair of costal plates, is nine inches ten lines. The total length of the carapace is eleven inches and a half.

The free end of the connate rib projects entire from the fifth, sixth, and seventh costal plates.

The character of the sculpturing of the outer surface of the costal plates is very similar to that in the *Tri. Henrici:* the tendency to the concentric arrangement of the raised lines is equally well marked in *Tri. Barbaræ,* and is accurately given in Mr. Erxleben's beautiful plate.

The carapace is not only more arched transversely, but it differs from that of *Tri. Henrici* in being slightly depressed along the middle line, as is indicated in fig. 2, Pl. 5.

This beautiful species of *Trionyx* is dedicated, with much respect, to its accomplished discoverer, Barbara, Marchioness of Hastings, and Baroness Grey de Ruthyn.

TRIONYX INCRASSATUS. *Owen.* Plates 26, 27, and 28.

This species of *Trionyx*, from Eocene formations of the Isle of Wight, resembles in general form the *Tri. Henrici* of the Hordwell sand, but differs from it in the anterior internal angle of the first costal plate (*pl*1, Pls. 26 and 27) being cut off, like that of the second and succeeding costal plates: it also differs in the greater length of the second costal plate as compared with the breadth of its outer end, and in the greater breadth of the outer end of the sixth costal plate (*pl*6, Pl. 26), the outer or terminal border of which is more convex. The nuchal plate (*ch*, Pl. 27) articulates with the whole anterior border of the first neural (*s*1) and costal plates (*pl*1), but sends backwards a process from near the middle of its posterior border, which fits into the space left between the truncated antero-internal angles of the first costal plates and the first neural plate. In this respect it resembles the nuchal plate of *Tri. Barbaræ* (Pl. 5), but the difference of general shape between this more delicately formed species, and the one under consideration, is well marked, and decisive as to their specific distinction. The

anterior border of the nuchal plate of *Tri. incrassatus* is smooth, slightly channeled, and feebly emarginate at the middle part; the plate sends out three short, tooth-like processes on each side; the posterior angle forms a fourth process which articulates with the true costal part, or end of the second rib, connate with the first costal plate (*pl*1). The first neural plate (*s*1, Pl. 27) is rather broader in proportion to its length than in the *Tri. Henrici.* The second (*s*2) and third (*s*3, Pl. 26) do not expand so much behind; the vermicular pattern is broken into distinct tubercles upon these plates. The posterior lateral sides of the hexagonal neural plates are relatively longer than in those of *Tri. Henrici.* The fifth neural plate (*s*5, Pl. 26) extends backwards beyond the fifth pair of costal plates (*pl*5, compare with Pl. 6) and articulates with the sixth pair of costal plates; but the eighth and part of the seventh neural plates are superseded by ossification, extending from the seventh and eighth pairs of costal plates to the median line, where those plates articulate with each other, as in the *Tri. Henrici* and *Tri. Barbaræ.* The inner surface of the nuchal plate (*ch*, fig. 2, Pl. 27) is divided by a transverse, slightly interrupted ridge, gently concave backwards, into two nearly equal parts; the posterior one being most excavated. The inner surface of the first costal plate (*pl*1, Pls. 26 and 27) presents the prominence (*c*2) left by the fracture of the vertebral end of the second rib, where it becomes connate with that plate, and also the oblique ridge (*c*1) formed by the attachment of the expanded end of the first short rib. The free end of the second rib (*c*2) is short, obtuse, depressed, convex above and flat below; the body of this rib has subsided to the level of the inner smooth surface of the costal plate, with which it has become completely blended. A small portion of the body of the second vertebra is preserved in connexion with the long neural arch, showing that it was slightly carinate at the under surface. The breadth of the third rib (*c*3), where it becomes connate with the second costal plate (*pl*2), is rather more than one third the breadth of that part of the plate; the rib at first sinks almost to the level of the under surface of the plate, and then gradually rises, increasing in breadth to its free extremity. The true pleurapophysial portions of the succeeding costal plates (4, 5, 6, 7, 8, and 9, Pl. 26) are better defined by outline grooves, but their degree of prominence is slight, except in the last pair (9), which have been liberated from the superincumbent costal plates (*pl*8) before they reached their posterior borders.

The minute accuracy and beauty of Mr. Erxleben's lithographs supersede the necessity of further verbal description of these rare and singularly well-preserved fossils.

Pl. 26 gives an inside view of the almost entire carapace of the *Tri. incrassatus;* and Pl. 27 gives an outside (fig. 1) and an inside view (fig. 2) of the fore part of the carapace of the largest individual of the same species of *Trionyx,* from the Isle of Wight, showing the nuchal plate (*ch*) in its natural articulation with the anterior neural and costal plates.

One character by which these carapaces differ from those of the *Tri. Henrici* or *Tri. Barbaræ* is the abrupt, almost vertical, border of the carapace, which is formed by the peripheral ends of the costal plates: these increasing in thickness as they approach that end, render the border characteristically thick: the specific name—*incrassatus*—has reference to this structure. The border is not grooved, and it is slightly produced above the projecting end of the subjacent rib, where it slopes a little down to the connate rib (Pl. 27, fig. 1). This structure will serve to distinguish a detached costal plate of the *Tri. incrassatus* from one of the *Tri. circumsulcatus* (Pl. 31, figs. 1, 2, 3); and the verticality and thickness of the margin will equally distinguish it from one of the *Tri. Henrici* or *Tri. Barbaræ.*

The chief value of the specimen (figured in Pl. 26) is derived from the fact, that several other bones of the same skeleton were discovered with it; and these I next proceed to describe.

Pl. 28, fig. 1, is the entosternal piece of the plastron, having the characteristic form of the chevron; it is broadest and most compressed at the median junction of the two crura, which increase in thickness and diminish in breadth as they diverge. The branches are relatively more slender than in the *Tri. Ægyptiacus** and *Tri. Javanicus*;† they resemble those of the *Tri. carinatus*‡ and *Tri. gangeticus.*§

Fig. 2 2′ is the lower branch of the left episternal: it is slender, gradually tapering to a point, flattened above or on the inner surface, convex behind, grooved along the margin next the entosternal. This piece, in its length and slenderness, resembles the corresponding part in the *Tri. carinatus* and *Tri. gangeticus.*

Fig. 3 3′ is the left hyposternal and part of the left hyosternal; the latter (*hs*) includes the mesial border, showing the relative extent of the angular part that sends off the ridged tooth-like processes, which are two in number, the anterior one notched or subdivided. The exterior, connate, rough, and tuberculate dermal plate stops at the base of these processes. The hyposternal (*ps*) has the nearest resemblance to that of the *Tri. gangeticus* figured by Cuvier,‖ but differs by the number of short toothed processes from its median and inferior border, and by the more slender base supporting the two long, lateral, striated, pointed processes. The tuberculate dermal plate covers all the exterior of the hyposternal to the roots of the pointed processes. The notch for the reception of the xiphisternal is rounded at the bottom.

Fig. 4 shows the long, rib-shaped, but straight scapula (51); its head forms two thirds of the glenoid cavity for the humerus; the body, flattened behind, convex in front, gradually contracts as it ascends, and terminates in an obtuse point; the

* Geoffroy, loc. cit., pl. 2, fig. B, *o*.

† Ibid., pl. 3, fig. B, *o*.

‡ Ibid., pl. 4, fig. B, *o*.

§ Cuvier, Ossemens Fossiles, tom. v, pt. ii, pl. 12, fig. 46.

‖ Loc. cit.

clavicular process (58) is shorter than the scapula, and slightly expands at its extremity. Both parts are longer and more slender than the homologous ones of the recent *Trionyx* figured by Cuvier.*

Fig. 5. The coracoid has the expanded, slightly curved form characteristic of the genus; it is not so broad as that figured by Cuvier.†

Fig. 6 is the iliac bone, short, thick, curved, subcompressed, attenuated and striated at its sacral extremity; the enlarged articular end is divided into three facets: two oblong and rough for sutural junction with the ischium and pubis; one smooth, and the smallest of the three, for the acetabulum.

Fig. 7 is the almost entire right femur; its convex, long oval head, bends inwards from between the two trochanters, of which the external and largest is broken off. The shaft bends backwards, and gradually expands to the feebly divided convex condyles. All the characteristics of the modifications of the femur in the *Trionyx* are here preserved.

Fig. 8 is a claw-bone, natural size.

Fig. 9 9′ 9″ are three views of the sixth cervical vertebra of the same *Trionyx*. This may be recognised by the broad, depressed, posterior surface of the centrum, partially divided into two cavities, side by side (*c′*); the seventh cervical has the two cavities there quite separated from each other; the fifth and preceding cervicals have the posterior surface of the centrum with a single cavity; so that the sixth cervical is the only one which has a single convexity in front (*c*, fig. 9′), and a double concavity (*c′*, fig. 9″) behind. The body is long, slender, compressed in the middle, with one median inferior ridge anteriorly, and a pair of inferior ridges posteriorly ending in hypophysial tuberosities (fig. 9, *yy*), which support, as it were, the posterior articular cups. A short, obtuse diapophysis projects from each side of the fore part of the centrum. The prezygapophyses (*z*) support slightly convex, oblong, articular surfaces; the zygapophyses (*z′*) are long, diverge, and support concave, oblong surfaces looking downwards. There is no spine; the neural arch is complete above the middle third of the centrum, the canal expanding towards both its wide, oblique outlets; this modification of course relates to the great extent of motion between contiguous vertebræ, and the necessity for providing against compression of the myelon during their rapid inflections and extensions.

The specimens of *Tri. incrassatus* here described are preserved in the Museum of the Marchioness of Hastings, by whose kind and liberal permission they, with other rare Chelonites, have been described and figured for the present work.

* Loc. cit., pl. 12, fig. 4.

† Loc. cit., pl. 12, fig. 4.

Trionyx marginatus. *Owen.* Plate 30.

A more obvious character than that pointed out at the peripheral border of the costal plate in *Trionyx incrassatus,* and serving better and more readily to determine such elements of the carapace, is the ridge with minute parallel striæ, which extends along the upper surface, close to the anterior and posterior borders of the costal plates in the species of *Trionyx* which I have on that account distinguished by the specific name of *marginatus.*

Mr. Erxleben has well given this character in the reduced view of the carapace (Pl. 30).

The border-pattern gradually becomes narrower and fades away before it reaches the outer end of the costal plates; it is also wanting on the anterior border of the first costal plate (*pl*1), and on the posterior border of the last (*pl*8).

The outer ends of the costal plates, which constitute the greater portion of the periphery of the carapace, are at first slightly bevelled off, and then vertically truncate; the sloping or bevelled part having the fine fibrous surface, which I have compared to coarse linen cloth. The vertical part of the border is slightly excavated in the fifth and sixth costal plates, but not so deeply as in the *Tri. circumsulcatus,* nor is the margin so thick in proportion to the length of the plate.

The neural plates are relatively smaller, in comparison to the costal plates, than in any of the foregoing species, but they agree in number; the eighth being suppressed, and the seventh reduced, in the same proportion as in *Tri. Henrici* and *Tri. Barbaræ,* by the median union of part of the seventh pair and of the eighth pair of costal plates. The fifth neural plate presents a simple oblong quadrilateral figure; the four neural plates in advance are six-sided, the two additional and shortest sides being formed by the truncation of the posterior angles; the sixth and seventh plates, on the contrary, have their anterior angles cut off. This modification in the form of the neural plates, and in their mode of juncture with the costal plates, relates to the opposite curvatures or inclinations of the costal plates, in the direction of the axis of the carapace: the anterior ones bending forwards, the posterior ones backwards, in addition to the curve common to all but the last pair of plates, transversely to the axis of the carapace, with the concavity downwards or towards the thoracic-abdominal chamber. The anterior internal angle of the second, third, and fourth costal plates is cut off; the posterior internal angle of the sixth, and both internal angles of the fifth pair of plates (*pl*5)

In these modifications of the form of the neural and costal plates, the *Tri. marginatus* agrees with the *Tri. Henrici* and *Tri. Barbaræ,* and differs from the *Tri. incrassatus,* in which all the neural plates but the seventh are six-sided, with the posterior internal angles truncated. Each of the costal plates, therefore, of the fifth

pair, in the *Tri. incrassatus,* differs from those of the three other species of *Trionyx* here described, in having only the antero-internal angles truncated, instead of both these and the postero-internal ones.

In the form and general proportions of the first pair of costal plates, the *Tri. marginatus* shows an intermediate character between the *Tri. Henrici* and *Tri. Barbaræ ;* in the great breadth of the peripheral end of the seventh pair of costal plates it differs in a well-marked degree from both species, and especially from the *Tri. Henrici,* which it most resembles in its general contour. In the *Tri. incrassatus* the seventh costal plates maintain nearly an uniform breadth from end to end.

The antero-posterior diameter of each of the triangular plates of the last costal pair exceeds the transverse diameter, whilst these proportions are reversed in *Tri. Henrici ;* the difference in part depending on the different form of the posterior border of the carapace in the *Tri. marginatus,* which is truncated ; the free borders of the last costal plates forming a straight transverse line. The marginal pattern of the costal plates may be traced in a slighter degree round the neural plates.

The reticular sculpturing is better defined, and of a coarser pattern in the *Tri. mar ginatus* than in any of the previously defined species.

The middle line of the carapace is slightly depressed, as in the *Tri. incrassatus.* The general degree of convexity of the carapace, which is less than that in the *Tri. Henrici* and *Tri. Barbaræ,* agrees also with that of the *Tri. incrassatus.*

The length of the carapace from the fore part of the first neural plate is eleven inches; its greatest breadth, across the suture between the third and fourth neural plate, is twelve inches.

This species is from the Eocene deposit at Hordwell Cliff, Hampshire: it was discovered by the Marchioness of Hastings, and is preserved in her ladyship's collection at Efford House.

TRIONYX RIVOSUS. *Owen.* Plate 29.

This beautiful species of *Trionyx,* also discovered by the Marchioness of Hastings in the Eocene beds at Hordwell Cliff, has fortunately a characteristic pattern of sculpturing, which, like that in the *Tri. marginatus,* would serve for the determination of detached portions of the carapace. Any of the costal plates, for example, of the posterior half of the carapace, figured in Pl. 29, might be distinguished by the sub-parallel longitudinal, and more or less wavy ridges, superadded to the more common reticulate sculpturing from the homologous parts of the carapace of any of the preceding fossil species of *Trionyx,* and, so far as I have yet seen, from any of the recent species.

The ridges in question, it will be understood, are longitudinal in respect of the

entire carapace; they would be transverse to the long diameter of the detached costal plate; they become more wavy as they recede from the neural plates. Of these only the sixth (*s*6) has been preserved in the specimen described; it differs in shape from that in any of the foregoing species, in being broader in proportion to its length; its greatest breadth being, as in *Tri. Henrici*, *Tri. Barbaræ*, and *Tri. marginatus*, across its anterior fourth part. The fifth neural plate, as in the species above cited, has been an oblong quadrate one, the fourth plate has had its postero-internal angles cut off, contrariwise to the sixth. The fifth costal plates have accordingly the same character of truncation of both their internal angles, though less marked anteriorly. A portion of the seventh and the entire eighth neural plates have been superseded, as in the other fossil *Trionyces*, by the median growth and junction of the seventh and eighth pairs of costal plates.

In the forms and proportions of these plates the present species agrees best with the *Tri. Henrici* and *Tri. incrassatus;* the latter species differs from it by the breadth and convexity of the sixth costal plates (*pl*6). The smooth connate ribs (5, 6, 7), shown on the under surface of the costal plates (Pl. 29, fig. 2), preserve a more uniform diameter, and do not expand in the degree shown in the *Tri. incrassatus* (Pl. 26, 5, 6, 7); the rib (8) attached to the costal plate (*pl*7) is straighter in *Tri. rivosus* than in *Tri. incrassatus.*

The projecting extremities of the ribs are beautifully preserved in the specimen of *Tri. rivosus* here described: their greater length, as compared with those attached to the fifth, sixth, and seventh costal plates in *Tri. Barbaræ* (Pl. 5), depends upon the nonage of the present specimen, which is figured in Pl. 29 of the natural size.

The peripheral borders of the costal plates are bevelled off obliquely from above downwards, and project a little where they join the end of the subjacent rib; the surface of this is finely and longitudinally striated. The reticulate sculpturing of the carapace extends to the sloping peripheral border, as it does to the vertical thick border of the carapace in *Tri. incrassatus;* it is not separated from the border by a marginal decussating fibrous surface, as in *Tri. marginatus*, *Tri. Henrici*, and *Tri. Barbaræ.*

The longitudinal ridges of the carapace, which form the chief distinctive character of the *Tri. rivosus*, offer an interesting though slight approach to the main feature of the carapace of the Luth or coriaceous soft turtle (*Spargis coriacea*); but in this existing species the longitudinal ridges or carinæ are straighter and more elevated, and the surface of the carapace is smooth at the interspaces. The less parallel and wavy course of the ridges in the present extinct *Trionyx* give a sinuous course to the intercepted spaces, like the furrows left by streams of water which have temporarily coursed over a sandy surface, whence the name "rivosus" proposed for the species.

Trionyx planus. *Owen.* Plate 32.

This species, like the *Tri. rivosus,* is represented by the posterior part only of the carapace, but the distinguishing characters are so well marked in it as to leave no doubt respecting the difference of the species from that of any of the above-defined *Trionyces.* The specimen consists of the last four pairs of costal plates, which are flat, with a coarse reticulate pattern on their upper surface, worn away towards the median end of the plates into a fossulate pattern, or detached pits; the reticulate sculpturing extends to the peripheral border of the costal plates, which is almost vertically cut down, and is scarcely at all produced where the attached rib projects: there is no marginal pattern along the anterior or posterior borders of the costal plate. The ribs are more neatly defined from the superincumbent costal plates than in any of the foregoing species, except, perhaps, the *Tri. rivosus.* The *Tri. planus* differs from them all in the complete obliteration of both the seventh and eighth neural plates, and by a partial obliteration of the sixth neural plate. This arises from a similar encroachment of ossification from the postero-internal borders of the sixth costal plates, upon the dermal cartilaginous matrix of the sixth neural plate, to that which happens in respect of the seventh neural and costal plates in the other *Trionyces*; whilst the whole of the seventh neural plate is superseded, as well as the eighth, and by the same encroachment of the corresponding pairs of costal plates.

These modifications and varieties of the osseous parts of the carapace are very significative of the essentially dermal nature of those parts, and show the small value and deceptive tendency of that developmental character on which Cuvier and Rathké have relied in pronouncing the neural plates to be developed spinous processes of vertebræ, and the costal plates to be expanded ribs. The connation of the seventh and eighth neural plates with the corresponding costal plates does not destroy their essential nature and existence, though it seems to make them part of the costal plates, any more than that connation with the neural arch in other *Chelonia* which seems to make them spinous processes.

Another distinctive character in the *Tri. planus,* as compared with the foregoing Eocene species, is the very close union, almost amounting to confluence, between the seventh and eighth costal plates of the same side, the original suture between which has been almost obliterated at their inferior surface.

In this character the *Tri. planus* resembles the *Tri. ferox,* Schweigger (*Gymnopus spiniferus,* Dum. and Bibr.), and *Tri. muticus,* Lesueur, but it differs from both by the flatness of its carapace, and the absence of any keel-like elevations upon its outer surface.

The middle of the posterior border of the carapace is slightly concave.

The specimen here described and figured was obtained by the Marchioness of

Hastings from the Eocene sand of Hordwell Cliff, and forms part of her ladyship's rich and instructive collection.

With the above portions of carapace, and apparently belonging to the same species of *Trionyx*, were found the two osseous plates, naturally and suturally united together, which are figured in Pl. 33, fig. 6, *hs, ps*; they present a similar coarse reticulate pattern on their external surface, with the same tendency to a concentric arrangement of the raised parts towards the periphery of the plate; their inner surface is smooth, slightly undulating, but upon the whole a little concave, and without any indication of adherent ribs. I regard them therefore as parts of the plastron, and they agree best with the hyosternal and hyposternal elements of the right side; yet differ in having no tooth-like processes extending from the inner border, which is convex instead of being concave, where the two elements join each other.

At the inner and anterior angle of the hyosternal there is, however, the fractured base of what was probably a tooth-like process; and there is similar evidence of such processes having extended from the posterior angle of the hyposternal, close to what I take to have been part of the notch for the xiphisternal.

These fragments at least show that the *Tri. planus*, or whatever species from Hordwell they belonged to, must have had a very different form of plastron from that of the *Tri. incrassatus* of the Isle of Wight, of which the conjoined hyosternal and hyposternal bones are figured in Pl. 28, figs. 3 and 3′, and from that plastron of which the hyposternal piece, from Bracklesham, is figured in Pl. 33, fig. 7.

Trionyx circumsulcatus. *Owen.* Plate 31, figs. 1, 2, and 3.

It may seem to have been hazarding too much to found a species on a single character when manifested by a single fragment of a carapace, which is all that at present represents such species; yet the character in question is so strongly marked, and so different from that of the same part of the carapace of any other fossil or recent species of *Trionyx*, that there appears to be no other alternative than to regard it as specific. The character in question is the groove or canal which is excavated in the thick vertical margin of the expanded free extremity of the fourth costal plate of the left side, figured in Pl. 31, figs. 1, 2, and 3. The vermicular sculpturing of the external surface of this plate, and its proportions and connexions with the connate rib, prove it to belong to the carapace of a *Trionyx*.

Previously to receiving this specimen from Lady Hastings, my attention had been drawn to the different modes in which the extremities of the costal plates of the different species of *Trionyx* were modified, in order to form the border of the carapace; sometimes obliquely bevelled down to an edge, as in the *Tri. Barbaræ* and the fragment of the *Trionyx pustulatus*, from Sheppy, figured in Pl. 31, 7—10; some-

times cut down vertically, or nearly so, as in the thickened border of *Tri. incrassatus;* sometimes with a marginal modification of the external sculpturing before the edge was formed, as in *Tri. marginatus;* sometimes without any such border-pattern, as in *Tri. rivosus.* But whatever character the border of a carapace has presented, has been constant in the same species, in which it is modified only at the fore part of the border formed by the nuchal plate, and at the back part formed by the short and small eighth pair of costal plates.

From this, therefore, it is to be inferred that the peculiar modification presented by the free border of the fourth costal plate (Pl. 31, fig. 3) was repeated in all the other costal plates, excepting, perhaps, the last pair; and consequently that the carapace was almost entirely surrounded by a thick, vertical border, deeply grooved,—a character which is expressed by the specific name *circumsulcatus,* selected to denote the Eocene *Trionyx,* represented by the fragment of the carapace here described.

This fragment, which consists as before said of the fourth costal plate of the left side, presents the common reticulate pattern of its external sculptured surface, but with some modifications not presented by the before-described species; the meshes are smaller near the ends of the plate than at its middle part, and the network is finest near the peripheral end. In the *Tri. marginatus* more particularly, and in a minor degree in *Tri. incrassatus,* the *Tri. Henrici,* and *Tri. Barbaræ,* we observe the raised parts of the network assuming a linear arrangement, more or less concentric, with the circumference of the carapace; but there is nothing of the kind observable in the *Tri. circumsulcatus.* In this species also the outer surface of the costal plate presents a distinct though slight double curvature; the usual convexity being changed into a concavity near the peripheral border: and, as the inner surface presents the usual uniform concavity, the peripheral part of the plate suddenly augments in thickness as it approaches the grooved border. (See fig. 2.) The character which distinguishes the *Tri. incrassatus* from *Tri. Henrici, Tri. Barbaræ,* and *Tri. rivosus,* is exaggerated in *Tri. circumsulcatus,* and there is added to it the groove, of which there is no trace in *Tri. incrassatus,* and but a feeble one in the fifth and sixth plates of *Tri. marginatus.*

The connate rib is almost wholly sunk into the substance of the superincumbent costal plate in the *Tri. circumsulcatus;* it is less prominent than in any of the foregoing species, especially at its distal part, which is also less expanded than in the *Tri. incrassatus.* The free extremity of the rib is entire, and is very short, as is shown in figure 1.

TRIONYX PUSTULATUS. Plate 31, figs. 7, 8, 9.

The contrast which the fragment above referred to, of apparently the homologous costal plate to the one last described, presents in the character of its peripheral

border, and in the prominence of the connate extremity of the rib on its under surface, is so great, as must impress the value of such characters upon the palæontologist. The outer surface of the present fragment presents a well-marked reticulate, or rather pustular, pattern, but a coarser one than in the *Tri. circumsulcatus.* The reticulation is continued to the beginning of the bevelled border in fig. 7, which slopes gradually to an edge; beneath which the free end of the rib projects. The *Tri. rivosus* most resembles the present fragment in this character.

The fragment is from Sheppy. I strongly suspect it to belong to a species distinct from any of those from Hordwell; and, in the hope of acquiring more illustrative specimens, the attention of collectors is directed to it by the specific name and the figure here given.

Trionyx. *Sp. ind.*, from Bracklesham. Plate 33, fig. 7.

The left hyposternal bone of the *Trionyx* from Bracklesham (figured in Pl. 33, fig. 7) resembles that from the Hordwell Eocene, referred to *Trionyx planus* (fig. 6, *ps*), in the convexity of the inner border at that part where it is concave in the *Tri. incrassatus* (Pl. 28, fig. 3, *ps*); but it differs from the *Tri. planus* in being uniformly convex as far as the xiphisternal notch, and is not indented before forming that notch, as it is in the *Tri. planus* (Pl. 33, fig. 6). The present hyposternal shows also very plainly the base of a fractured tooth-like process of the subjacent hæmapophysis projecting from the inner border, where there is no such trace of a process in the *Tri. planus.* There are also the bases of a tooth-like process on both sides of the xiphisternal notch, and at the posterior outer angle of the hyposternal bone. The external border of the bone in advance of these processes is longer and straighter than in the corresponding part of the hyposternal of the *Tri. incrassatus.*

The species of *Trionyx* from Bracklesham cannot, however, be safely defined until the characters of its carapace are known. The present specimen forms part of the valuable and instructive collection of Frederick Dixon, Esq., F.G.S.

§ 4. *Family* Paludinosa.

This family, if regard were had to the number of species it contains, might be deemed the typical one of the order *Chelonia.* But in the series of extinct species, from the particular formation of Great Britain, to which the present and foregoing sections relate, the number of marsh tortoises is small in comparison with those that were more truly aquatic (*Fluvialia*), and which inhabited the sea (*Marina*); and such a result might have been anticipated from the nature of their matrix, as it is elucidated by other classes of fossil animals, the remains of which are round in the London clay.

The feet of the *Paludinosa* have the digits comparatively free; more than three

toes, as in *Tetronyx*, Lesson, and usually all five, are armed with claws, and are united together by a web only at their base; but the extent of this web and the length and flexibility of the digits vary in the different species and sub-genera, and accordingly they manifest various degrees of aptitude for swimming, or for climbing the banks of the streams or marshes which they habitually frequent, and for walking on dry land.

The costal plates extend, in the mature individuals, to the ends of the ribs, and articulate with the marginal plates; the dermal pieces of the plastron are co-extensive with the abdominal integument, and unite together by suture so as to form an unbroken expanse of bone; the sides of which, formed by part of the hyosternals and hyposternals, unite with a corresponding proportion of the lateral borders of the carapace. There is a gradation in the degree of convexity of the carapace, and in the angle at which the sides of the plastron bend up to join the carapace, which progressively brings the marsh tortoises nearer to the true land tortoises (*Terrestria*), and some of the steps in this progression of affinities are illustrated by the fossils from the London clay.

Those that, by the flatness of their carapace and plastron, depart least from the fluviatile forms of the order will be first described.

Genus—Platemys.

Platemys Bullockii. *Owen.* Plate 4.

Report on British Fossil Reptiles, Trans. British Association, 1841, p. 164.

Amongst the fossil Chelonians of the London clay, the portable dwelling-house of which was provided with side walls as well as a floor and roof, are some tolerably large species, remarkable for the lowness of the roof of their abode, and especially for the flatness of its floor.

A rigid comparison of the numerous species of the marsh-dwelling Chelonians, which the active researches of naturalists have brought within the domain of science, has led to their classification into several groups, to which generic or sub-generic names are attached, and the fine preservation of the characteristic part of the skeleton of the specimen from Sheppy, figured in Pl. 4, gives the opportunity for determining to which of these subdivisions of the genus *Emys* of Bronguiart that specimen belongs.

In my 'Report on British Fossil Reptiles,' the result of these comparisons, as regards the present fossil, were simply indicated by the sub-generic name, and I confined myself to a description of the specific distinctions noticeable in the only example I had then seen.

The present species differs from all those to which MM. Dumeril and Bibron

restrict the term *Emys*,* by the presence of a thirteenth scute—the intergular one (*ig*. Pl. 4) upon the plastron; from the genera *Cistudo* and *Kinosternon* it differs by the absence of any moveable joint between the parts of the plastron; from the *Tetronyx* by the rounded anterior border of the plastron, and the greater number of scutes that have left their impressions upon it: it resembles the genus *Platysternon* in the flatness of the plastron and the horizontality of its lateral prolongations; but it differs from the only known species of that genus in the contour of the sternum, which is elliptical and rounded in front, and has the lateral prolongations one third the length of the entire sternum. It has also the intergular scute, which is absent in the *Platysternon*, as in the *Emydes* of Dumeril and Bibron. The presence of this scute, so plainly indicated at *ig* in the petrified plastron from Sheppy, together with the impressions of six pairs of the more constant scutes of the plastron, indicate that the depressed form of the probably estuary terrapene to which that plastron belonged, has appertained to the section which the eminent French Erpetologists above cited have called *Pleurodères*, or those that could retract their neck beneath the side only of the anterior aperture of their thoracic abdominal case.

From the genus *Peltocephalus* the fossil under comparison differs by the marginal position of both gular (*gu*) and intergular (*ig*) scutes, and by the slight narrow emargination of its posterior extremity (*xs*). An outline of the natural size of this emargination is added in the plate.

It more nearly resembles the *Podocnemys expansa* in the forms and proportions of the plastron scutes; but the three anterior ones (*gu*, *gu*, and *ig*), are not wedged in (*enclavées*) between the humeral scutes (*hu*), but are on a plane anterior to them.

The form and proportions of the plastron in certain species of the *Platemys*, Dumeril and Bibron, and the number and relative position of the scutes which covered it, offer the nearest resemblance to those of the present fossil, and, with the results of the foregoing comparisons, have determined my reference of the specimen in question to that genus.

Like the *Platemys Spixii* (*Emys depressa* of Spix), *Platemys radiolata*, *Platemys gibba*, and some others of the genus, the sternum is rounded at its anterior border, and notched at its posterior and narrower extremity.

The intergular scute (*ig*) which crosses the median suture of the episternals (*es*) is sub-pentangular and larger than either of the gular pair; its point encroaches a little upon the entosternal bone (*s*). The gular scutes (*gu*) are triangular, and, with the intergular one, cover the anterior border of the plastron.

The humeral or brachial scutes (*hu*) are inequilateral quadrate plates; the pectoral scutes (*pe*) and the abdominal scutes (*ab*) are transversely oblong and quadrate. The femoral scutes are inequilaterally quadrate, the posterior external angles being prolonged and rounded off. The anal scutes would be sub-rhomboidal were the posterior

* Erpétologie Générale, 8vo, 1835, tom. ii, p. 232.

end of the plastron entire. There are impressions of three scutes—the axillary, the inguinal, and a supplementary one,—upon each lateral prolongation of the plastron, covering the suture between this and the marginal plates of the carapace (*aa*), in which the present fossil resembles the *Platysternon* or large-headed *Emys* of China; but the lateral walls are relatively longer, being equal in antero-posterior extent to one third the same diameter of the entire plastron; whilst in the subgenus *Platysternon* they are less than one fourth. The general form of the plastron is also very different; in the *Platysternon megacephalum*, e. g. the plastron has an oblong quadrilateral figure, with an open-angled notch behind.

Retaining, then, the present species in the genus *Platemys*, as defined by Duméril and Bibron, we find that it enters into that small minority of the group in which the plastron is rounded instead of being truncate anteriorly.

In the present remarkable fossil the plastron forms almost a long ellipse, the hinder, division being very little narrower, but tending to an apex, which is cut off by a shallow emargination. The lateral walls, of the length above defined, extend outwards almost parallel with the plane of the sternum, and expand to join by a wavy or rather zigzag suture the marginal plates; six of these (*a a a a a a*) are preserved on each side; their lower sides form a very open angle with the lateral walls: but the fractures of these parts indicate that their horizontality may be in part due to accidental pressure.

The anterior part of the entosternal (*s*) is bounded by two nearly straight lines, converging forwards at an angle of 65°, with the apex rounded off; the posterior contour of this bone is nearly semicircular. The length of the entosternal is two inches ten lines; its breadth three inches seven lines; the forms and relative positions of the other elements of the plastron are sufficiently illustrated by Pl. 4: *es, es* marks the extent of the left episternal; *hs, hs* are the hyosternals; *ps* the hyposternals; *xs* the xiphisternals.

The chief peculiarity of this plastron is the intercalation of a supernumerary piece of bone, bearing the letters *pe* and *ab* between the hyosternal and hyposternal elements on each side; so that the middle third of the plastron is crossed by two transverse sutures instead of one; each suture being similarly interrupted in the middle by an angular deflection from the right, half an inch back, to the left side.

The extremities of the transverse sutures terminate each at the apex formed by the inner or lower border of the parallel marginal plates. The first or anterior of these sutures is distant from the anterior margin of the plastron six inches five lines; the second suture is distant from the same margin eight inches nine lines; the right half of the suture, which is a few lines in advance of the left, is the part from which these measurements are taken.

Since this deviation is rare, it having been noticed for the first time in the original description of the present specimen, a naturalist, not having the specimen at hand for

comparison, might at first be led to suspect that the transverse impressions of the second (pectoral) or third (abdominal) pairs of scutes had here been mistaken for a suture; but due care was observed to avoid this error; the scutes of the plastron have left obvious impressions at *pe*, *fe*, which prove that they were in the same number as in the Platemydians generally, and were quite distinct from the sutures in question.

Thus the intergular scute (*ig*) is in the form of an ancient shield; the gular scutes (*gu*) are small inequilateral triangles, with their posterior border parallel with that of the succeeding pair of scutes. The posterior transverse boundary of these,—the humeral scutes (*hu*)—crosses the plastron four inches and a half from its anterior margin; that of the pectoral pair of scutes crosses at seven inches and a half from the anterior border, and between the two transverse sutures; that of the abdominal pair (*ab*) at ten inches distant from the anterior margin, and about one inch and a quarter behind the second transverse suture; passing straight across the plastron between the posterior concave margins of the lateral wall. The posterior boundary of the fifth or femoral pair of scutes (*fe*) inclines obliquely backwards from the median line, as usual; it is three inches behind the preceding transverse impression.

It is in the interspace of these impressions that traces of the transverse suture between the hyposternals and xiphisternals are obvious, about four inches from the posterior extremity of the plastron. If these traces were not so obvious, it might be supposed that the xiphisternals were of unusual length, entering into the formation of the lateral wall, and extending backwards from the second transverse suture to the end of the plastron; but this disproportion would be hardly less anomalous than the existence of the additional pair of bones intercalated between the hyo- and hyposternals which the present fossil evidently displays.

In most of the existing large *Emydes* and *Platemydes*, the median transverse suture traverses the plastron a little behind the third pair of scutes, and so crosses the fourth or abdominal pair (*ab*, *ab*); and according to this analogy, the second transverse suture in the fossil agrees with the single one ordinarily present, and has most right to be regarded as the normal boundary between the hyo- and hyposternals. One of the most distinctive characters of the present extinct *Platemys* is, therefore, the division of each hyosternal into two, the plastron consisting of eleven instead of nine pieces; if the very interesting anomaly which it displays be not an accidental or individual variety. Viewed in the latter light, its explanation is suggested by that homology of the hyosternals and hyposternals which determines them to be connate and expanded abdominal ribs (hæmapophyses), and thus we may view the oldest of the known Platemydians as exhibiting, like many other extinct forms, a nearer approach to the more typical condition of the abdominal ribs, as they are shown, e. g. in the *Plesiosaurus*. Whereas, on Geoffroy's hypothesis, that the plastron is the homologue of the sternum of the bird, it would be a further deviation from that type.

The fine example of *Platemys Bullockii,* here described and figured, was purchased for the British Museum at the sale of Mr. Bullock's collection.

I am happy in the opportunity of expressing my acknowledgments to Charles König, K.H., F.R.S., for the urbanity with which every requisite facility was afforded.

PLATEMYS BOWERBANKII. *Owen.* Plate 39.

Report on British Fossil Reptiles, Trans. British Association, 1841, p. 163.

This species is represented by a fine specimen exhibiting not only the plastron (fig. 2), but likewise a great portion of the carapace (fig. 1), from Sheppy, in the rich collection of the fossil remains from that island in the possession of J. S. Bowerbank, Esq., F.R.S. It equals in size the *Platemys Bullockii,* in the British Museum, but differs in the absence of the finely punctate character of the exterior surface of the bones; in the greater antero-posterior extent of the lateral walls, and the longer curves which they form in extending from the body of the plastron.

The carapace (fig. 1) presents the same equality of breadth of the neural plates (s_2—s_7) as in the *Emys testudiniformis;* but they diminish more rapidly in length as they recede in position; and the whole carapace is much more depressed; it is flat along its middle tract. The sixth neural plate (s_6) is a hexagon of nearly equal sides; the seventh (s_7) is a pentagon; the mesial or vertebral ends of the seventh pair of costal plates (pl_7) meet and unite behind it, so as to conceal or supersede the eighth neural plate. In the circumstance of the neural plates decreasing in length without losing breadth, as well as in the mutual junction of the seventh costal plates, the present fossil resembles the Sheppy carapace from Mr. Crow's collection, which Cuvier has figured, and which may, therefore, have belonged to the present species of *Platemys.*

The plastron (fig. 2) is thirteen inches in length and ten inches in breadth; it is rather broader before than behind, rounded at the anterior border, with a shallow emargination at the middle of the posterior border, but wider than in the *Platemys Bullockii,* and with the angles on each side rounded off. The under surface is nearly flat, slightly convex at the fore part, and as slightly concave behind. The lateral walls uniting the plastron to the carapace are five inches in antero-posterior extent.

The entosternal (*s*) resembles that of the *Platemys Bullockii* in general form, but is longer than it is broad, instead of the reverse proportions. The two anterior sides meet at a right angle. The episternals (*es*) are broadest behind. The middle part of the plastron is almost equally divided between the hyosternals (*hs*) and hyposternals (*ps*). There is a trace of the intercalary piece (*hp*), which is seen extending across the plastron of the *Platemys Bullockii;* here it is wedged into the outer interspace of those bones, like one of the external portions of the composite abdominal ribs in the Plesiosaur. In the relative length of the lateral walls the *Platemys depressa* most resembles the present species.

Genus—EMYS.

EMYS TESTUDINIFORMIS. *Owen.* Plate 36.

Report on British Fossil Reptiles, Trans. British Association, 1841, p. 161.

EMYS DE SHEPPY. *Cuv.* (?)

From the preceding genus of the *Chelonia paludinosa* the present species differs in the depth of the bony cuirass, the convexity of the carapace, and the concavity of the plastron (Pl. 36, fig. 6). The more immediate affinities of the present fossil are elucidated by the comparison of the points of structure which it displays with the anatomical characters of the carapace of the *Platemys* and *Testudo*.

The specimen, on which the species here called *Emys testudiniformis* is founded, includes a large proportion of the first, second, third, fourth, fifth, and sixth, with a fragment of the seventh costal plates of the left side; a small proportion of the second, third, fourth, fifth, and sixth neural plates; the hyosternals and hyposternals, and part of the entosternal bones of the plastron.

The first costal plate is one inch ten lines in greatest breadth, one inch five lines broad at its junction with the neural plates, and four fifths of the vertebral margin is articulated with the second neural plate; one fifth part, divided by an angle from the preceding, joins a corresponding side of the lateral angle of the third neural plate; in this structure it resembles both the genus *Testudo* and some species of *Emys*.

The third, fourth, fifth, and sixth neural plates are of equal breadth, as in *Emydes*; not alternately broad and narrow as in the *Testudines*; they are likewise of uniform figure, as in most *Emydes*; not variable, as in *Testudines*; the neural plates also resemble those of the existing *Emydes*, and particularly of the Box-terrapin (*Cistudo*) in form. The lateral margin of each is bounded by two lines, meeting at an open angle, the anterior line is only one fourth part the length of the posterior one; and this resemblance may be stated with confidence, since the portion of the entosternal piece preserved in the plastron determines the anterior part of the fossil.

The costal plates preserved in the present Chelonite differ from the corresponding ones of the tortoises, and resemble those of the *Emydes* in their regular breadth, and the uniform figure of the extremities articulated with the vertebral pieces; the anterior line of the angular extremity is nearly three times as long as the posterior one.

Further evidence of the relation of the present Chelonite to the fresh-water family is given by the impressions of the epidermal scutes; those covering the vertebral plates (*scuta vertebralia*) agree with those of most *Emydians* in the very slight production of the angle at the middle of their lateral margins, which is bounded by a line running parallel with the axis of the carapace, except where it bends out to form that small angle.

The middle part of each side of the plastron, in the *Emys testudiniformis*, is joined to the carapace by a strong and uninterrupted bony wall, continued from a large proportion of the hyosternal and hyposternal bones upwards to the marginal costal pieces. The median margin of the hyosternals and hyposternals are articulated together by a linear suture, traversing the median line of the plastron, and only broken by a slight angle formed by the right hyposternal, which is a little larger than the left. A similar inequality is not unusual in both tortoises (*Testudinidæ*) and terrapenes (*Emydidæ*). The transverse suture is, of course, broken by the same inequality; that portion which runs between the left hyosternals and hyposternals being two or three lines in advance of the one between the right hyosternals and hyposternals. The posterior half of the broad entosternal piece is articulated to a semicircular emargination at the middle of the hyosternals; so that the whole plastron forms one continuous plate of bone. This is relatively thicker than in existing *Emydes*, resembling in its strength that of tortoises; and it is likewise slightly concave in the middle, which structure is more common in tortoises than in Emydians, save those in which the sternum is moveable; in most of the other species the sternum is flat or slightly convex.

I have shown in my paper on the Turtles of Sheppy,* that the carapace figured by Cuvier† was not sufficiently perfect to decide the affinities of the Chelonian to which it belonged; if the vertebral scutes were less broad and angular than in marine turtles, the neural plates—much less variable in their proportions—were, on the other hand, as narrow as in turtles. But with reference to the plastron of the Sheppy Chelonite, figured by Parkinson,‡ and supposed by Cuvier to belong to an *Emys* of the same species as the carapace above alluded to, I have been able to determine, by an examination of the original specimen in the museum of Professor Bell, that it belonged to the marine genus *Chelone* and to the species *longiceps*. In the fossil *Emys* in Mr. Bowerbank's collection, the plastron being in great part preserved, establishes its nonconformity with the marine turtles, and manifests a striking difference from Parkinson's fossil plastron.

The entosternal piece is impressed, as in Tortoises and Emydes, by the median longitudinal furrow, dividing the two humeral scutes; the transverse linear impression dividing the humeral from the pectoral scutes traverses the hyosternals half an inch behind the suture of the entosternal; the second transverse line, which divides the pectoral from the abdominal scutes, is not so near the first as in tortoises, but bears the same relation to the transverse suture of the plastron as in most Emydes; it does not pass straight across the plastron, but the right half inclines obliquely inward to a more posterior part of the median suture than is touched by the left half. The third transverse line, which divides the abdominal from the femoral scutes, passes straight

* Geological Proceedings, December 1, 1841.

† Ossemens Fossiles, tom. v, part iv, pl. 15, fig. 12.

‡ Organic Remains, vol. iii, pl. 18, fig. 2.

across the plastron between the posterior ends of the bony lateral walls, uniting the carapace and plastron.

	Inches.	Lines.
The breadth of the plastron is	5	10
The outer posterior extent of the lateral wall is	3	9
The breadth of the entosternum	1	5
The depth of the whole bony cuirass at the middle line is .	4	0

In the convexity of the carapace and relative depth of the osseous box, the Sheppy Chelonite slightly surpasses most existing species, resembling in this respect the *Emys ocellata* and *Cistudo Carolina.* The plastron is also slightly concave, as in the male of *Cistudo vulgaris:* it is, however, entire at the line where the transverse joint of the plastron exists in the box-tortoises; and the extent and firm ossification of the lateral supporting walls of the carapace forbid likewise a reference of the fossil to those genera.

The general characters of the present fossil, more especially the uniformity of size and breadth of the preserved vertebral plates and ribs, prove it to be essentially related to the fresh-water or Emydian Tortoises. It exceeded in size, however, almost all known Emydians, and was almost double the dimensions of the Emydian species (*Cistudo Europea*) now inhabiting central Europe. It appears, like the *Cistudines,* to have approached the form of the land tortoises, in the convexity of the carapace, but without possessing that division and hinge of the plastron which peculiarly distinguishes the box-tortoises. The contraction of the anterior aperture of the bony cuirass, especially transversely as compared with the *Platemydians,* would indicate more restricted powers of swimming, and consequently more terrestrial habits. In the thickness and strength of the bones of the buckler, especially of the sternum, we may discern an approach to the genus *Testudo.*

Assuming that the Chelonite here described may be identical with that of which the carapace from Mr. Crow's collection is figured in the 'Ossemens Fossiles,'* the "*Emys de Sheppy*" of Cuvier will be one of the "synonyms" of the present species. Mr. Gray, in his 'Synopsis Reptilium,' 8vo, 1831, has given Latin names to all the fossil reptiles indicated or established by Cuvier, and has called the "*Emys de Sheppy*" "*Emys Parkinsonii,*" referring as representations of this species, not to the figure of the carapace above cited, which may belong to the same species as the present *Emys,* but to the figure of the plastron, copied by Cuvier from Parkinson's 'Organic Remains,' and to the figure of the skull in the same work, both of which most unquestionably belong to the genus *Chelone* and not to the genus *Emys.*

The "*Emys Parkinsonii*" of Mr. Gray is a synonym of my *Chelone longiceps.* Cuvier's name,—which, besides the claim of priority, is the result of laborious and direct comparison devoted to the elucidation of its subject,—if rendered into Latin would be *Emys toliapicus;* but as the species to which it refers may not be the one

* Ed. 1824, vol. v, part ii, pl. 15, fig. 12.

here described, and is by no means the only fresh-water tortoise which the clay of Sheppy has yielded ; and since the characters of the present species have not hitherto been defined nor its affinities to the land tortoises been pointed out, the interests of science appeared to me to be best consulted by giving a distinct name to the present species.

The fossil here described is from the Eocene clay of Sheppy Island, and forms part of the collection of J. S. Bowerbank, Esq., F.R.S.

Emys lævis. *Bell.* Plate 3.

The only specimen I have seen of this species, I obtained from Sheppy a few months since, and it is now in my collection. It has some remarkable peculiarities which distinguish it, at first sight, from every other species of Emydian, either recent or fossil.

The specimen is imperfect at each extremity ; the carapace wanting anteriorly the nuchal plate, and posteriorly from the eighth neural plate inclusive. The contour of the carapace is remarkably even, free from all inequalities of surface, and forming, from side to side, nearly a perfect segment of a circle, uninterrupted by either carina or depression of any kind. The whole surface of the bone also is remarkably smooth.

The first neural plate (fig. 1, *s*1) is narrow, being not more than two fifths as broad as it is long; the sides parallel for the first two thirds of its length, then slightly narrowed ; its sides are not interrupted by the costal sutures, as the posterior margin of the first costal plate (*pl*1) joins the anterior part of the second neural. The second, third, and fourth neural plates (*s*2—*s*4) are of an elongated hexagonal form, and nearly resemble each other ; the fifth, sixth, and seventh (*s*5—*s*7) are also hexagonal, but each shorter than the preceding one ; the sixth is narrowed somewhat abruptly, and the seventh still more so, the latter being also shorter than it is broad.

Although the posterior part of the carapace is considerably broken, there appears evidently to be an interval between the seventh and eighth neural plates ; at which part the posterior portion of the seventh costal plate and the anterior portion of the eighth approximate to the corresponding plates of the opposite side, on the median line, without the intervention of the neural plates ; a peculiarity which I do not remember to have seen in any other of the *Emydidæ*.

The first costal plate occupies in its breadth the whole length of the first neural, and the anterior fifth only of the second ; but in consequence of the gradual shortening of the neural plates in the portion of each, posterior to the angle at which the costal sutures join them, the seventh neural receives the costal suture at about the middle of its length.

The marginal plates (fig. 3, *a*, *a*, *a*) are broad, smooth, and curved evenly to the edge, where they turn under at nearly a right angle.

The second and third vertebral scutes ($v2$, 3) are twice as broad as they are long, the outer angles being nearly right angles; and this must be, to a great extent, a permanent character, as the specimen is evidently not young. The fourth vertebral scute ($v4$) is hexagonal, and its breadth is about one fourth greater than its length.

Of the plastron (fig. 2), the whole of the anterior portion is wanting, including the entosternal, the episternals, and a portion of the hyosternals; and the posterior portion has lost the greater part of the xiphisternals. The bones which remain form a broad, somewhat convex, uniform surface.

The most remarkable circumstance connected with this part of the osseous box is the existence of a pair of intercalated, irregularly-formed bones (*hp*), which stand between the marginal portion of the hyosternal (*hs*) and hyposternal bones. These would appear to represent the pair of additional bones which will be seen in *Platemys Bullockii* (Pl. 4), stretching across between the hyosternals and hyposternals, and, in the latter case, meeting like them in the median line.

I have examined many skeletons of Emydes, but have never observed any similar structure in this genus; but in the genus *Terrapene*, including the ordinary box-tortoises, there appears to be, in some cases, a rudiment of a corresponding bone.*

The total length of the carapace of this specimen, judging from comparison with perfect recent examples of the same genus, was probably rather more than eight inches, and its breadth is six inches.

T. B.

Emys Comptoni. *Bell.* Plate 2.

The beautiful specimen of fresh-water Chelonia which forms the subject of the present description, is in the collection of the Marquis of Northampton, who has kindly allowed it to be figured for this work, and to whose respected name it is dedicated.

The general form of this species, as well as many details of its structure, is so similar to that of a typical land tortoise, that it is difficult at first to reconcile its aspect with the idea of its being at all aquatic in its affinities. It is, however, doubtless a true Emys; and although the present specimen is a young one, its characters are sufficiently marked to enable us to distinguish it from every other. The costal plates

* The sternal bones appear liable to occasional curious anomalous variations. Thus, while in *Platemys* there is a perfect pair of intercalated bones between the hyosternals and the hyposternals, and in the present species an approach to a similar interpolation, we find, on the contrary, in *Gymnopus*, a genus of Trionychidæ, the only skeleton of which in this country I have now in my possession, the hyosternals and hyposternals constitute but a single bone on each side, a peculiarity which I believe to be perfectly unique in the whole of the Chelonian order. [T. B.]

had not become ossified to the extremity of the ribs, and there is consequently a space between the costal and marginal plates, interrupted by the free extremities of the ribs, which just reach to the marginal plates. It is the only specimen of the family which I have seen, amongst the fossil Chelonian remains, in which the whole series of neural plates, with the nuchal and pygal, remain without material injury; and the plastron is also nearly entire.

The nuchal plate (fig. 1, *ch*) would form a triangle with its posterior angle obtuse, but that this angle is truncated for its articulation with the first neural (*s*1). This latter plate is quadrate, a little longer than broad, and rather narrowed forwards. The second (*s*2) and third (*s*3) are also quadrate, and nearly equilateral, The fourth (*s*4) is, however, rendered hexagonal by the termination of the costal suture at a short distance from the anterior margin; it is quite as broad as it is long. The fifth neural plate (*s*5) is of a similar form, but notably longer than it is broad, forming a broad hexagon, with the lateral angles nearer the anterior than the posterior margins. The seventh (*s*7) is the only one which forms a nearly symmetrical hexagon, broader than it is long, but with the lateral angles equidistant from the anterior to the posterior margins. The eighth and ninth neural plates (*s*8, 9) are regularly quadrate, the former being broader than it is long, the latter forming a perfect square. It is very remarkable how much more closely the seventh and following neural plates to the tenth are united than any of the anterior ones; indeed the sutures between the seventh and eighth, and between the eighth and ninth, are with difficulty observable, notwithstanding the youth of the individual. The tenth neural (*s*10) and the pygal (*p*) plates are somewhat injured and bent down abruptly by some violence.

I have dwelt somewhat in detail upon the direction of these plates, as their characters evidently bear upon the near relation of this species to the terrestrial type already alluded to.

The internal margin of the first costal plate (*pl*1) exactly coincides with the length of the first neural. The second and fourth costal plates (*pl*2, 4) expand towards the margin of the carapace, and the third and fifth (*pl*3, 5) become narrower in the same direction in a similar degree.

The marginal plates present no important peculiarity in this young specimen.

With regard to the impressions left by the horny scutes, we find that although they are of the ordinary general form, they are less broad and spreading in proportion to their length, than is ordinarily the case in the *Emydidæ*, and particularly in immature age; thus offering another character approaching the terrestrial type.

The plastron (fig. 2) is tolerably perfect, and presents the remarkable expanse which ordinarily characterises the land and fresh-water forms, but especially the former; and the anterior and posterior openings between the carapace and the plastron, for the exit and play of the extremities, are somewhat contracted, and thus appear scarcely to afford sufficient room for the natatorial habits of an aquatic species.

The entosternal plate (*s*) forms an almost regular rhomb; the episternals (*es*) are much broken, and offer no peculiarity in the parts which remain; nor is there, in the general form of the hyosternals (*hs*) or hyposternals (*ps*), or the xiphisternals (*xs*), anything which calls for particular notice.

The contour of the bony case, viewed as a whole, bears out the close relation to the terrestrial form which I have assigned to this species. The slightly curved costal regions of the carapace, and the even flatness of the vertebral portion, as well as the outline of the dorsum, when viewed laterally, show a very striking approximation to the small African species of true Testudo, *T. areolata*, and still more to *T. signata*. But if its geological position did not of itself preclude our considering it as belonging to a terrestrial group, the structure of many parts of its osteology would be sufficient to justify our considering it as a true Emydian.

	Inches.
Length of the carapace	3·2
Breadth of ditto	2·9
Height of the bony case	1·3

T. B.

EMYS BICARINATA. *Bell.* Plates 34 and 35.*

The specimen before me, the only one which I have yet met with of this species, is very large, and, from the close union of the bones, and the nearly obliterated condition of the sutures, is evidently of considerable age; a fact also attested by the forms of the vertebral scutes (*v*2, *v*3, *v*4, Pl. 34), which have become greatly narrowed in proportion to their length.

The general outline of the carapace must have been nearly orbicular. The elevation moderate; the part occupied by the vertebral scutes, and about half an inch on each side of them, flattened; and this plain portion bounded on each side by a low obtuse carina, which is itself obscurely and irregularly grooved longitudinally. The sides are considerably sloping, with but a slight curvature.

The carapace is wanting anteriorly in nearly the whole of the nuchal plate, and posteriorly from the tenth neural inclusive. At the sides a few fragments only of the marginal plates exist.

The first neural plate (*s*1) is nearly oval, and, as usual in this family, is wholly included within the first pair of costal plates; it is considerably longer than any of the succeeding ones. The second neural (*s*2) is nearly as broad as it is long, the anterior angles truncated as usual, posteriorly somewhat narrowed; the third neural (*s*3) has the peculiarity of being longer than even the second, and is less narrowed behind; the fourth to the seventh inclusive (*s*4-7) are gradually shorter, the seventh forming a broad hexagon, with the lateral angles (meeting the costal suture) nearly midway

* The name is wrongly inscribed *tricarinata* on the Plates.

between the anterior and posterior margins. The eighth (*s*8) is also broader than it is long, but the lateral angle is near the anterior margin, as in the preceding plates. The ninth (*s*9) is somewhat expanded posteriorly, but less so than usual.

The sixth and seventh of the neural plates are considerably raised towards the centre, but with a slight longitudinal depression along the median line; and there is a considerable triangular or wedge-shaped elevation, commencing with its base near the anterior margin of the eighth, and extending to the posterior margin of the ninth neural plate.

The costal plates (*pl*1—8) differ from those of the species in general in being more regularly parallel at their lateral margins.

The first vertebral scute reaches to the posterior third of the first neural plate (*v*1), and its lateral margins are expanded forwards, but with a slight curve. The second and third (*v*2, 3) have nearly parallel sides, and are both longer than they are broad, the lateral angles being extremely inconsiderable; the fourth (*v*4) is hexagonal, but still with short lateral angles; the fifth (*v*5) has the lateral margins, and, as usual, becomes broader posteriorly.

As the costal or lateral scutes depend, in the only important and variable part of their contour, on the form of the margins of the vertebral, itis unnecessary to describe them.

The plastron (Pl. 35) occupies about its usual relative proportion to the carapace, but it has been so much broken as to afford but little opportunity for any satisfactory or useful description. It would appear, however, from the extent of the openings for the passage of the limbs, that the animal must have possessed considerable powers of swimming, offering in this respect a very marked contrast to the testudiniform character of *E. Comptoni* and *E. testudiniformis*.

	Foot.	Inches.	Lines.
Probable total length of the carapace	1	0	0
Probable total breadth of ditto	0	10	0
Depth of the bony case	0	3	3

T. B.

EMYS DELABECHII. *Bell.* Plate 37.

An almost gigantic specimen of the fluviatile form of scutate Chelonia, in the collection of the Geological Survey, forms the subject of the present description. It is from the London clay of the Island of Sheppy.

This species far surpasses in size any known Emydian, whether fossil or recent; the carapace having been certainly not less than one foot nine inches in length and one foot five inches in breadth. It very clearly belongs to the form to which I have assigned it, and in some of its broader characters approximates considerably to the last species, *E. bicarinata.* The specimen is, however, unfortunately so badly injured, partly by having been originally much crushed, and partly by recent disintegration,

from the decomposition of the pyrites with which it is extensively permeated, that the description must necessarily be confined to little more than general contour.

The osseous case is somewhat less deep, in proportion to its probable length and breadth, than in *E. bicarinata*, as will be seen by a comparison of their dimensions; it is consequently less sloped at the sides, which are also less curved. There is not the slightest indication of a carina, either median or lateral; but the whole vertebral region is simply flattened.

I have already had occasion to observe, that as the scutate Chelonians continue to grow, the vertebral scutes are observed to alter their form, and the relative proportion of their longitudinal and transverse diameters. This takes place particularly by the comparative abbreviation of the angular lateral projections which meet the line of junction of the margins of the corresponding costal scutes. These angles, as the animal grows, and as the scutes increase in size, become comparatively much shorter and more obtuse; and to such an extent does this take place, that in many species the sides of the vertebral scutes become very nearly parallel in old age; as may be observed in the figure of *E. bicarinata* (Pl. 34, *v*2, *v*3, *v*4), and in most recent species.

Now the specimen at present under notice, notwithstanding its great size, exhibits this indication of old age, even in a less degree than in the figured specimen of *E. bicarinata*. We could not, therefore, even if other distinctive characters were absent, for a moment confound them as one species.

In longitudinal dimensions the scutes in question ordinarily increase in proportion to the growth of the animal; and afford, in the examination of mutilated fossil Chelonian remains, approximating data for ascertaining the general size of the animal; the second and third vertebral scutes, taken together, being generally rather less than two fifths of the total length of the carapace.

The edge of the present specimen, and the injuries it has undergone, combine to render any satisfactory account of the vertebral series of osseous plates impossible; the nuchal and pygal plates being absent, and the neural wholly indistinguishable; and the plastron has been even more mutilated than the carapace.

The impressions of the vertebral scutes are tolerably perfect, as far as regards the second (*v*2), third (*v*3), and fourth (*v*4). The second and third are about as broad as they are long, irregularly hexagonal, and the lateral angles are but moderately produced; the third has the posterior margin shorter than the anterior; the fourth is rather longer than it is broad, and notably narrowed posteriorly.

The plastron exhibits at least the usual expanse of form which belongs to the typical *Emydes*, but its condition is such as to preclude any detailed description.

	Feet.	Inches.	Lines.
Probable length of the carapace	1	9	0
Probable breadth of ditto	1	5	0
Depth	0	4	8

Such are the meagre details to which we are restricted in describing by far the largest of all the fossil species of this genus. I have the gratification of offering it by name to my distinguished friend Sir Henry De la Bèche, through whose kindness I have the opportunity of including it in the present Monograph.

T. B.

FRAGMENTARY REMAINS OF EMYDIANS.

EMYS CRASSUS. Plate 38.

From several such specimens kindly transmitted to me by the Marchioness of Hastings, I have selected for the subjects of Pl. 38 two portions of a plastron; viz. the hyosternal (figs. 1, 1′) and the hyposternal (figs. 2, 2′). They are chiefly remarkable for their thickness (fig. 3), and also for their size in other dimensions.

The hyosternal shows on its outer surface (fig. 1) very strong impressions of the interspace or union between the humeral and pectoral scutes, and between the pectoral and abdominal scutes. The hyposternal shows the same kind of impression between the abdominal and femoral scutes.

These specimens were discovered in the Eocene sand at Hordwell, and are in the museum of the Marchioness of Hastings.

In Pl. 36, figs. 1—5, are figured some portions of the carapace of an *Emys*, from the Eocene deposits on the north shore of the Isle of Wight. These also form part of the collection of the Marchioness of Hastings.

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Platemys Bowerbankii (?). Plate 40, figs. 1, 2.

The evidence of species of Chelonia of the Fresh-water or Marsh-dwelling family, *Paludinosa,* has hitherto been derived only from such parts of the skeleton of the trunk as have been described, figured, and referred to the genera *Platemys* and *Emys,* in the foregoing pages 62-76.

Since those pages were sent to press, Mr. Bowerbank has been so fortunate as to obtain from the Eocene clay at Sheppy the portion of fossil skull, of which two views are given of the natural size in Plate 40, figs. 1, 2. If these figures, and especially the side view, fig. 1, be compared with the corresponding view of the skulls, Pl. 11, fig. 1; Pl. 12, fig. 1; Pl. 17 *A,* fig. 1, or Pl. 25, fig. 1, a marked difference will be discerned in the form and proportion of the orbit, which is smaller and more nearly circular in fig. 1, Pl. 40.

But the bony chamber for the eyeball forms one of the characters by which the skull is distinguished in the marine and fresh-water families of the order *Chelonia.* The orbit, for example, is always much larger in proportion to the entire skull in the marine species, and commonly of the oval form, which is preserved in the beautiful fossil skull of the *Chelone cuneiceps,* Pl. 11, fig. 1; or with the upper and outer part even more produced and angular than is there represented. In the families *Fluvialia* (Trionyx) and *Paludinosa* (Emydians), the orbit is not merely much smaller in proportion to the skull, it is circular, or nearly so, and not produced at the upper and outer angle. By this character, we are led to refer the fossil skull under description to the fresh-water division of the Chelonian order.

Our choice between the Fluviatile or Paludinose families of that division is guided by the formation of the border of the orbit, and by the proportionate length and the form of the face or muzzle in advance of it.

In the species of *Emys* (*Podocnemys expansa*) which I have selected for comparison, as offering upon the whole the nearest approach, which any Chelonian skull at my command gives, to the unique fossil in question, the malar bone (*i,* in Cuvier's figure of the skull of *Emys expansa,* pl. xi, fig. 9, of the 'Ossemens Fossiles,' tom. v, pt. ii, 1825; 26 in the figure of the fossil, fig. 1, Pl. 40), becomes much contracted as it approaches the orbit, to which it contributes a small part of the posterior border. In the *Chelones* the malar bone forms a larger proportion of the orbital rim (see Cuvier, tom. cit., pl. xi, fig. 1 *i*), and contributes more to its under than its back part, which is chiefly formed by the characteristically large postfrontal 12 (*g* in Cuvier's figs.); and this character was manifested in the ancient Eocene turtles as well as in the modern species, as may be seen by reference to the bones numbered 26 and 12, in Pl. 11, fig. 1; Pl. 17 *A,* fig. 1, of the present work. The superior maxillary bone 21 (*b* in Cuvier's figs.) is longer in the *Emys,* extends

further back in the orbit, and is deeper at its posterior termination, than in the *Chelones*. In all these characters, derived from the bones entering into the formation of the orbit, the fossil under comparison agrees with the *Emys*, and, indeed, departs further from the *Chelones* than the *Podocnemys expansa* does, by the much smaller proportion in which the anteriorly contracted malar bone (26) contributes to the rim of the orbit. In the *Trionyces*, the malar bone forms a larger proportion of the border of the orbit than in the *Podocnemys expansa*, and *a fortiori*, than in the fossil in question.

The choice between the Fluviatile or Paludinose tribes of the fresh-water Chelonians, in the determination of this fossil, is better guided by the form and proportions of the skull anterior to the orbit. In the recent *Trionyces* the muzzle is more acute, and in most of them more prolonged than in the Emydians, with which the fossil skull agrees in the shortness of the muzzle; whilst it departs further than most recent Emydians from the *Trionycidæ*, in the broad truncated character of its anterior termination. There is also a very well-marked character of affinity to the *Podocnemys expansa*, in the smooth and shallow canal which extends from the fore part of the orbit forwards to the border of the external nostril across the upper part or nasal process of the superior maxillary bone (21). This groove is very accurately represented in fig. 1, Pl. 40, in the fossil; it is rather broader in proportion to its length in the *Podocnemys expansa;* but so far as it has depended upon the presence and arrangement of the facial scutes, it is decisive against the fossil having appertained to any species of soft turtle (*Trionyx*), in which such epidermal parts were entirely wanting.

The marks of the supracranial scutes in the fossil are, as in some Emydians, too feebly and obscurely traceable to permit of a satisfactory comparison of their arrangement. The exterior surface of the prefrontal (16), frontal (11), postfrontal (12), and parietal (7) bones is subreticulate. The substance of the bones is thick and coarsely cancellous. The nasal bone is connate with the prefrontal, as in most modern Emydians; in the proportion of this compound bone the fossil resembles more the ordinary Emydians (*Emys europæa*, e. g.) than it does the *Podocnemys expansa.* The border of the prefronto-nasal forming the upper part of the nostril is thick and rounded; as is also the lateral border of the same cavity formed by the maxillary. The lower part of this border of the maxillary shows the suture for the premaxillary, which must have presented similar proportions to the premaxillary of the *Podocnemys expansa* and other Emydians. The shape of the frontal (11), the proportion of the upper border of the orbit which it forms, and the course of its sutures with the contiguous bones, are clearly indicated in fig. 2, Pl. 40. The straight line formed by the suture between the frontal (11) and postfrontal (12) resembles that in the *Podocnemys expansa;* it is bent or curved in the *Chelones*. To what extent the postfrontal (12) was continued backwards, whether so, as with the parietal, to roof over the temporal fossa, as in the *Podocnemys expansa*,* or, in a less degree, leaving that fossa open superiorly, as in the Emydians

* See Cuvier, loc. cit., pl. xi, fig. 1 *a*.

generally, is a question which will require for its determination a more perfect specimen than the fossil under description. The thickness, however, of the fractured posterior part of the postfrontal indicates that the bone had been broken not very close to its natural posterior border, on the supposition that this was free, as in the Emydians generally; and the part of the suture of the postfrontal with the parietal which has been preserved, extends obliquely outwards and backwards, as in *Podocnemys expansa*, not directly backwards, as in most of the *Emydes* with open temporal fossæ. (Compare Cuvier, loc. cit., fig. 10 with fig. 14, the suture between *g* and *h*.) With respect to the parietal bones (7), these are too much mutilated to show more than the position and extent of the coronal suture.

A few words may be perhaps expected relative to the difference which the fossil in question presents to the land-tortoises. In comparison with the skull of a *Testudo indica* of corresponding dimensions with the fossil, the larger proportional size of the orbits distinguishes the skull of that terrestrial species almost as strongly as the same character does the skull of the marine turtles. But in addition to this, the malar bone forms a larger proportion of the back part of the orbit in the *Testudo*, and the prefronto-nasal part of the skull is more bent down; the suture between the frontals and prefrontals describes a curve convex forwards in the *Testudo*, whilst it deviates very little from a straight line in the fossil, and that little is convex backwards. The extent also of the upper surface of the postfrontals and parietals, so far as these are preserved in the fossil, is greater than the whole of those bones in the land-tortoise compared.

Having been led by the foregoing comparisons to refer the fragment of the fossil skull (Pl. 40, figs. 1, 2) to the family *Paludinosa*, it is reasonable to conjecture that it may have appertained to some one of the large Emydians, which we already know to have left their carapaces in the Eocene clay of Sheppy. One commonly finds in the recent skeletons of Emydians, that any particular character of the exterior surface of the bones of the trunk is repeated on the upper surface at least of the bones of the head. This comparison, in the present instance, indisposes me to regard the fossil in question as having belonged to the *Emys levis*, or to the *Emys bicarinata*, or to the *Platemys Bullockii* with the punctate plastron. I should be rather led to select the *Platemys Bowerbankii* from the character in question, as exhibited by the carapace and plastron described at p. 66. But in provisionally registering the fossil skull in question under the name of *Platemys Bowerbankii*, I should wish to be understood as by no means vouching for the accuracy of the reference. The conjecture rests solely on the character above referred to, which is far from being decisive; and its only value is, that it happens to be the only one by which we can be guided at present in forming any opinion at all as to the specific relations of the fossil in question.

CHAPTER II.—Order *CROCODILIA.*

CROCODILES, ALLIGATORS, GAVIALS.

Of the numerous and various kinds of Reptiles, the fossil remains of which have been discovered in the tertiary and secondary strata of Great Britain, many are found to have their nearest representatives, amongst the actual members of the class, in the present order; and here more particularly in the long and narrow-snouted genus called, through a corrupt latinization of its native name, *Gavialis*, which is now represented by the Gavial or, more properly, Garrhiāl, of the river Ganges.

In the interpretation of the fossil remains of Reptiles, no skeleton has more frequently to be referred to than that of the Gavial or Crocodile, or has thrown more light on the nature of those singularly-modified forms of the class which have long since passed away.

It is accordingly requisite for the palæontologist who would describe the fossil remains of reptiles, to make himself, in the first place, thoroughly conversant with the osteology of the recent *Crocodilia.* This knowledge can be gained only by assiduous study of the skeletons themselves, with the aid of the best descriptions, or the guide of a competent teacher. But to enable the reader to follow or comprehend the description of the fossil Saurians, some elementary account of the Crocodilian skeleton is at least necessary, accompanied with illustrations of the parts which, in the sequel, will have to be frequently referred to under special or technical names.

In Pl. 1 (*Crocodilia*) is given a reduced or miniature side view of the skeleton of a Gavial which was twenty-five feet in length—dimensions which are rarely found to be surpassed in the present day. Beneath it is a restoration of the skeleton of the Teleosaur, or extinct Gavial of the Triassic or Oolitic period, showing how closely the general type of conformation has been adhered to, the modifications of the more ancient form of Crocodile evidently adapting it for moving with greater speed and facility through the water, and indicating it to have been more strictly aquatic, and probably marine.

The particular nature of these modifications will be explained when I come to describe the Crocodiles of the secondary strata. I propose at present to give a preliminary sketch of the osteology of the recent *Crocodilia.*

A glance at a natural or well-articulated skeleton of one of these reptiles, such as

is figured in Pl. 1, will show that it consists mainly of a series of segments, more or less alike. From the back of the head to the end of the tail, the chief part of each segment consists of a cylindrical portion or 'body,' differing only in its proportions, and diminishing as it recedes from the trunk. Every segment sends a plate of bone upwards from its upper or dorsal surface, which plate or 'spine' is supported by an arch of bone, except in the diminishing segments at the end of the tail.

Other plates of bone, of more variable forms and dimensions, project from each side of the segments of the trunk and basal part of the tail. In a less proportion, but still in a great number of the segments, an arch of bone is formed below, or on the ventral side of the cylindrical body; but this lower arch is more variable in its proportions and mode of composition than the upper arch: it is open or incomplete in the neck. Under all these variations, however, there is plainly manifested a fundamental unity of plan in the composition of the different segments, which have accordingly received the common appellation of 'vertebra.'

For the convenience of description, the vertebræ are divided, though somewhat arbitrarily, into groups bearing special or specific names. Those next the head, with the inferior arch incomplete below, are called 'cervical vertebræ;' they are usually nine in number: those that follow with the inferior arch closed below, or which have the laterally projecting parts slender and freely moveable, are called 'dorsal vertebræ:' the other vertebræ of the trunk that have no lateral moveable appendages, are called 'lumbar vertebræ;' the last vertebræ of the trunk, always two in number in the *Crocodilia*, the inferior arches of which coalesce to support and be supported by the hind limbs, are the 'sacral vertebræ;' the segments of the tail are the 'coccygeal,' or 'caudal vertebræ,' whether they possess or not an inferior arch, or whatever other modifications they may offer.

These names, 'cervical,' 'dorsal,' 'lumbar,' 'sacral,' 'coccygeal,' were originally applied to corresponding segments or vertebræ in the human skeleton, from the study of which the nomenclature of osteology takes its date: it may well be supposed, therefore, that a classification and designation of vertebræ based upon knowledge limited to their characters in a single example of the vertebrated series, and that example one in which the common type has been most departed from, to adapt it to the peculiar attitude and powers of the human species, would fall far short of what is required to express the general ideas derived from a comparison of all the leading modifications of the vertebrate skeleton; and accordingly the anatomist who passes from a previous acquaintance with human osteology only, to the study of those of the lower Vertebrata, finds that he has to rectify, in the first place, the erroneous notions which anthropotomy has taught him of the nature of the primary segment of his own and other vertebrated skeletons, and to acquire true ideas, with the concomitant nomenclature, of the essential constituents or anatomical elements of such segment.

In human anatomy, for example, the costal elements are only recognised when they

retain throughout life that distinctness, or moveable union with the rest of their segment, which they manifest at their first appearance; and they are then classified as distinct bones from the rest of their segment, to which the term 'vertebra' is restricted, and which is equally regarded as a single bone; as, e. g., in the dorsal region of the skeleton. In the cervical region the whole segment is called 'vertebra,' and is recognised as the equivalent bone to a dorsal vertebra, although it includes the costal elements, because these have coalesced with the rest of their segment, which anchylosis is misinterpreted as a mere modification of a transverse process; and the 'cervical vertebra' is distinguished by having that process 'perforated,' and not entire as in the other vertebræ.

But, in the Crocodile, the embryonic condition of the cervical ribs in Man is retained throughout life; and, therefore, if we were to be guided by the characters laid down by the recognised authorities in anthropotomy for the classification of its vertebræ, we should seek in vain for any vertebræ with "transverse processes perforated for the transmission of vertebral arteries," whilst we should find all the vertebræ from the head to the loins, "with articular surfaces, either on their sides or their transverse processes, where they join with ribs," and should accordingly have to reckon these as "dorsal vertebræ."

These and many similar instances which might be adduced, have compelled me to premise a few brief explanations of the principles and nomenclature by which I shall describe the fossil remains of the *Reptilia*, and illustrate their nature by reference to the skeletons of their existing representatives, in the present Work.

The primary segment of the skeleton of all Vertebrata is a natural group of bones, which may be severally recognised and defined under all the modifications to which such segment may have been subjected in subservient adaptation to the habits and exigencies of a particular species.

A view of such a segment, as it exists in the thorax of the crocodile, the tortoise, and the bird, is given at p. 5.

The part marked *c* is the 'centrum,' or body of the vertebral segment; it is always developed originally as a separate element, and retains its character of individuality in the tortoise and crocodile. The bony arch above the centrum was formed originally by two distinct side-plates,—the 'neurapophyses,' *n*, which coalesce with one another at their summits and thence develope a median plate or process of bone called the 'neural spine' *ns*. Other bony processes which shoot out from the neurapophyses are more variable, and will be afterwards noticed. The arch so formed coalesces with the centrum in the bird, and constitutes an apparently single bone, to which, in anthropotomy, the name 'vertebra' would be restricted. But it would be as reasonable to confine it to the central element (*c*) in the tortoise and crocodile; for the parts of the inferior arch are not less essentially parts of the same natural segment, than the neurapophyses which have formed the upper arch. The next pair of elements,

then, which we have to notice, is marked in figs. 4, 5, and 6, *pl*, signifying 'pleurapophysis,' the name of these elements. In the segments figured they retain their primitive distinctness, and acquire unusual length, in order to aid in encompassing the dilated canal or cavity for the heart and lungs; so modified, these elements are commonly called 'ribs,' or 'vertebral ribs.'

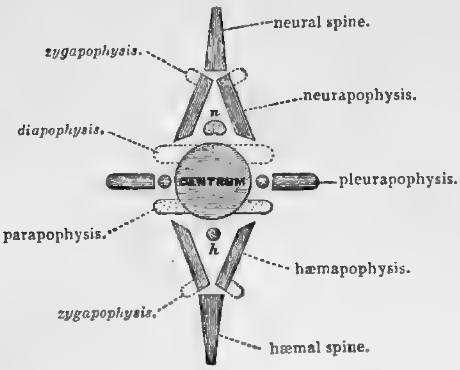
The elements more constantly employed to protect the vascular or 'hæmal' axis, in other words, to form the inferior or hæmal canal, are those marked *h* in figs. 4 and 6; they are the 'hæmapophyses,' which are usually articulated, like the neurapophyses, with the centrum, but are displaced by the great centres of the vascular system in the thorax, where they have got the special name of 'sternal ribs,' and also that of 'costal cartilages,' or 'cartilages of the ribs,' when they do not become ossified. The hæmal arch in the thorax is usually completed by a median element (*hs*), called a 'hæmal spine,' but which itself becomes vastly expanded in the bird (fig. 4); it is, nevertheless, the part in the hæmal arch which repeats below, or answers to the part (*ns*) in the upper arch. In the segments of the trunk and tail, the element (*ns*) retains its normal size and form as a 'neural spine;' but where the central axis of the nervous system becomes unusually developed, as in the head, e. g., analogous to the development of the vascular centres in the chest, the neural canal is correspondingly expanded, and the cavity acquires a special name, and is called 'cranium,' just as the analogously expanded hæmal canal is called 'thorax.' Into the formation of the wall of the cranium other vertebral elements enter besides the neurapophyses, those e. g. which are numbered 8 and 12 in figs. 10 and 11; the neural spine (7 and 11 in the same figures) retains its primitive distinctness, is expanded horizontally, and, like the 'sternum' in the thorax of the bird (*hs*, fig. 4, p. 5), it receives a special name, e. g. 'parietal' in fig. 10, and 'frontal' in fig. 11. The elements *a a* (figs. 4 and 6) form a symmetrical pair of bones or cartilages, attached at one end to the hæmal arch, and projecting outwards and backwards. These are the 'prosartemata,' or appendages; they are, of all the elements of the vertebral segment, those that are least constant in regard to their presence, and, when present, are subject to the greatest amount of development and metamorphosis: they become, e. g., the opercular bones in the frontal segment of the fish; the branchiostegal rays in the parietal segment; and the pectoral fins in the occipital segment, and they are developed into the fore limbs and hind limbs, the arms, wings, and legs of other Vertebrata.*

As the nervous and vascular centres become reduced in size, the bony canals or arches protecting them are simplified and contracted, and the vertebra assumes a symmetrical character. In the Crocodile, the hæmal arch, in the tail, e. g., is formed by the hæmapophyses, which ascend and articulate directly with the centrum; the pleurapophyses are shortened, directed outwards, and become anchylosed to

* The facts and arguments in support of this conclusion, are detailed in my works 'On the Nature of Limbs,' and 'On the Archetype of the Vertebrate Skeleton,' 8vo (Van Voorst).

form 'transverse processes;' but such a vertebra, when analysed as it is developed, resolves itself very nearly into the ideal type given in the subjoined diagrammatic cut (fig. 7); *n* is the neural axis, called 'myelon,' or 'spinal marrow;' *h* is the hæmal axis, the chief trunk of which is called 'aorta,' and 'caudal artery.' The names of the vertebral elements which, being usually developed from distinct centres, are called 'autogenous,' are printed in Roman type; the italics denote the 'exogenous' parts, more properly called 'processes,' which shoot out from the preceding elements.

Fig. 7.



Ideal typical vertebra.

On comparing this form of the primary segment with that figured in Cut 4, p. 5, it will be seen that they differ by altered proportions with some change of position of certain elements; but every modification resulting in the various forms of the parts of the skeleton figured in Pl. 1, has its seat in one or other of the segmental or 'vertebral' elements above defined; and the same principle I believe that I have established with regard to the internal skeleton in all vertebrate animals.

With this preliminary explanation, the nature and relations to the typical vertebra of the parts of the Crocodilian vertebræ, figured in Plates 1 *D*, 3, will be, it is hoped, readily appreciated. In Plate 1 *D*, in which are figured some of the most perfectly-preserved fossil reptilian vertebræ which have hitherto been discovered, the elements and processes are indicated by the initial letter of their names. Figs. 1 and 2 give a side view and a back view of a cervical vertebra, apparently the fourth, of the *Crocodilus Hastingsiæ*, from the Eocene deposits at Hordwell; *c* is the centrum, *n* the neural canal formed by the neurapophyses, which have coalesced superiorly with each other, and with the neural spine (*ns*). Inferiorly they articulate by a suture (which is shown by the wavy line on each side of the process *d* in fig. 1) with the centrum; *pl* is the pleurapophysis, which articulates by two parts, the lower one called the 'head' to the process from the centrum, the upper one called the 'tubercle' to the process from the neurapophysis; beyond the union of the head and tubercle, the pleurapophysis projects freely outwards and downwards, but instead of being elongated in that direction, it becomes expanded in the direction of the axis of the body, i. e. forwards and backwards, and so acquires a shape which has given rise to the name 'hatchet bone' or 'hatchet-shaped process,' * applied to this element in the *Plesiosaurus*.

* "To compensate for the weakness that would have attended this great elongation of the neck, the *Plesiosaurus* had an addition of a series of hatchet-shaped processes on each side of the lower part of the cervical vertebra." (Buckland, Bridgewater Treatise, vol. i, p. 206, and vol. ii, p. 30, 1836.)

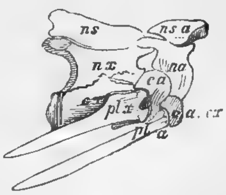
Cuvier recognised in these lateral bones, "en forme de hache," the homologues of the "petites côtes cervicales" of the Crocodile. (Ossemens Fossiles, 4to, tom. v, pt. ii, p. 479, 1824.) And Conybeare had

The purport of this modification is the same in the *Crocodilia* as that which seems to be more called for in the *Plesiosaurus,* viz. to augment the strength of the cervical region of the skeleton ; and this is so effectually done by the overlapping of the hatchet-shaped ribs of this region in the *Crocodilia,* as shown in Plate 1, that the flexibility of the neck is much restricted, although the joint of the head allows that part to be bent from side to side at nearly right angles with the neck. When, however, the head is held firmly forwards by its powerful muscles, the imbricated vertebræ of the neck transmit with great effect the impulse which the strong and long tail gives to the rest of the body in the act of swimming.

In fig. 3 the cervical vertebra is represented minus its pleurapophyses, and it answers accordingly to that portion of the natural segment to which the term 'vertebra' is usually restricted in the dorsal region of the trunk. The exogenous processes shown in this view of the vertebra are, *p,* the 'parapophysis' or inferior transverse process, developed from the centrum ; *d,* the 'diapophysis' or upper transverse process developed, as in most cases it is, from the neurapophysis ; *z, z',* are the 'zygapophyses' or 'oblique processes,' which, from their function in articulating together contiguous vertebræ, are also called 'articular processes.' In most of the cervical, and in some of the dorsal, vertebræ of the Crocodile, an exogenous process is developed from the under surface of the centrum, called 'hypapophysis ;' it is indicated by the letters *hy* in fig. 2. In some species it is double,* and beneath the atlas it becomes 'autogenous' or is developed as a separate element, *ca, ex,* fig. 8, in which condition the part is found beneath the centrums of two or three of the anterior cervical vertebræ in the Ichthyosaurus.†

The first and second vertebræ of the neck are peculiarly modified in most air-breathing Vertebrata, and have accordingly received the special names, the one of 'atlas,' the other of 'axis.' In Comparative Anatomy these become arbitrary terms, the properties being soon lost which suggested those names to the human anatomist; the 'atlas' e. g. has no power of rotation upon the 'axis' in the Crocodile, and it is only in the upright skeleton of man that the large globular head is sustained upon the shoulder-like processes of the 'atlas.' In the Crocodile, these vertebræ are concealed by the peculiarly prolonged angle of the lower jaw in the side view of the skeleton in Plate 1, and a woodcut of the two vertebræ is therefore subjoined. The pleurapophyses are

Fig. 8.



Atlas and Axis vertebræ of the Crocodile.

previously extended the same homology to the "particularly prominent wing-like appendages to the transverse processes in many of the long-necked quadrupeds, and the long styloid processes of the cervical vertebra of birds." (See his admirable Memoir of June 14th, 1822, in the Geol. Trans., 2d series, vol. i, p. 384.)

* In *Crocodilus basifissus,* e. g., see the Quarterly Journal of the Geological Society, November 1849, p. 381, pl. x, fig. 2.

† This interesting discovery was communicated by its author, Sir Philip de M. Grey Egerton, Bart., to the Geological Society of London, in 1836, and is published in the fifth volume of the second series of their Transactions, p. 187, pl. 14.

retained in both segments, as in all the other vertebræ of the trunk. That of the atlas, fig. 8, pl. *a*, is a simple slender style, articulated by the head only, to the independently developed inferior part of the centrum, or 'hypapophysis' (*ca, ex*). The neurapophyses (*na*) of the atlas retain their primitive distinctness; each rests in part upon the proper body of the atlas (*ca*), in part upon the hypapophysis. The neural spine (*ns, a*) is also here an independent part, and rests upon the upper extremities of the neurapophyses. It is broad and flat, and prepares us for the further metamorphosis of the corresponding element in the cranial vertebræ.

The centrum of the atlas (*ca*), called the odontoid process of the axis in Human Anatomy, here supports the abnormally-advanced rib of the axis vertebra, which in some *Crocodilia* is articulated by a bifurcate extremity, like the ribs of the succeeding cervical vertebræ; but it is not expanded or hatchet-shaped at the free extremity. The proper centrum of the axis vertebra (*cx*) is the only one in the cervical series which does not support a rib; it articulates by suture with its neurapophyses (*nx*), and is characterised by having its anterior surface flat, and its posterior one convex.

With the exception of the two sacral vertebræ, the bodies of which have one articular surface flat and the other concave, and of the first caudal vertebra, the body of which has both articular surfaces convex, the bodies of all the vertebræ beyond the axis have the anterior articular surface concave, and the posterior one convex, and articulate with one another by ball-and-socket joints. This type of vertebra, which I have termed 'procœlian,'* characterises all the existing genera and species of the family *Crocodilia,* with all the extinct species of the tertiary periods, and also two extinct species of the Greensand formation in New Jersey.† Here, so far as our present knowledge extends, the type was lost, and other dispositions of the articular surfaces of the centrum occur in the vertebræ of the *Crocodilia* of the older secondary formations. The only known Crocodilian genus of the periods antecedent to the Chalk and Greensand deposits with vertebræ articulated together by ball-and-socket joints, have the position of the cup and the ball the reverse of that in the modern Crocodiles, and the genus, thus characterised by vertebræ of the 'opisthocœlian' type, has accordingly been termed *Streptospondylus*, signifying 'vertebræ reversed.' The aspects of the zygapophyses are, however, more constant; the anterior ones, Pl. 1 *D*, fig. 3 *z*, look obliquely inwards; the posterior ones, ib. *z'*, obliquely outwards. In a vertical section, therefore, of a Crocodilian vertebra, such as is figured in Pl. 4, fig. 3, the smooth, flattened inner surface of the anterior zygapophysis is turned towards the observer, and the convex outer surface of the posterior zygapophysis. Thus the anterior and posterior extremity of the vertebra being determined by observation of the aspect and direction of the zygapophyses, it is at once seen whether the body has the procœlian structure, as in Pl. 4, fig. 3, or the opisthocœlian structure, as in fig. 4. But the most prevalent type

* Προς, before; κοιλος, concave.

† Quarterly Journal of the Geological Society, November 1849.

of vertebra amongst the Crocodilia of the secondary periods was that in which both articular surfaces of the centrum were concave, but in a less degree than in the single concave surface of the vertebræ united by ball and socket. A section of a vertebra of this 'amphicœlian' type, such as existed in the *Teleosaurus* and *Steneosaurus*, is figured in Pl. 4, fig. 6. In the *Ichthyosaurus*, the concave surfaces are usually deepened to the extent and in the form shown in fig. 7. Some of the most gigantic of the *Crocodilia* of the secondary strata had one end of the vertebral centrum flattened, and the other (hinder) end concave; this 'platycœlian' type we find in the dorsal and caudal vertebræ of the gigantic *Cetiosaurus* (Pl. 4, fig. 5).

With a few exceptions, all the modern Reptiles of the order *Lacertilia* have the same procœlian type of vertebræ as the modern *Crocodilia*, and the same structure prevailed as far back as the period of the *Mosasaurus*, and in some smaller members of the Lacertilian order in the Cretaceous and Wealden epochs.

Resuming the special description of the osteology of the modern *Crocodilia*, we find the procœlian type of centrum established in the third cervical, which is shorter but broader than the second; a parapophysis is developed from the side of the centrum, and a diapophysis from the base of the neural arch; the pleurapophysis is shorter, its fixed extremity is bifid, articulating to the two above-named processes; its free extremity expands, and its anterior angle is directed forwards to abut against the inner surface of the extremity of the rib of both the axis and atlas, whilst its posterior prolongation overlaps the rib of the fourth vertebra.

The same general characters and imbricated coadaptation of the ribs characterise the succeeding cervical vertebræ to the seventh inclusive, the hypapophysis (*hy*, fig. 2, Pl. 1 *D*) progressively though slightly increasing in size. In the eighth cervical the rib becomes elongated and slender; the anterior angle is almost or quite suppressed, and the posterior one more developed and produced more downwards, so as to form the body of the rib, which terminates, however, in a free point. In the ninth cervical the rib is increased in length, but is still what would be termed a 'false' or 'floating rib' in anthropotomy.

In the succeeding vertebra the pleurapophysis articulates with a hæmapophysis, and the hæmal arch is completed by a hæmal spine; and by this completion of the typical segment we distinguish the commencement of the series of dorsal vertebræ. With regard to the so-called 'perforation of the transverse process,' this equally exists in the present vertebra, as in the cervicals, as may be seen by comparing fig. 6, p. 5, with fig. 2, Pl. 1 *D*; in both, the foramen is the vacuity intercepted between the bifurcate extremity of the rib and the rest of the vertebra with which that rib articulates; and, on the other hand, the cervical vertebræ equally show surfaces for the articulation of ribs. Cuvier, in including the proximal portions of the ribs with the rest of the vertebra, in his figure of a dorsal vertebra of a Crocodile, * so far follows nature, and produces a parallel to

* Ossemens Fossiles, 4to, tom. v, pt. ii, pl. iv, fig. 4.

his figure of a cervical vertebra; but the entire natural vertebra or segment includes the parts delineated in outline in Cut 6, p. 5. In that figure is shown the semiossified bar *h'* which is interposed between the pleurapophysis *pl* and hæmapophysis *h* in the Crocodilia and some existing Lizards. The typical characters of the segment due to the completion of both neural and hæmal arches, is continued in some species of *Crocodilia* to the sixteenth, in some (*Crocodilus acutus*) to the eighteenth vertebra. In the *Crocodilus acutus* and the *Alligator lucius*, the hæmapophysis of the eighth dorsal rib (seventeenth segment from the head) joins that of the antecedent vertebra. The pleurapophyses project freely outwards, and become 'floating ribs' in the eighteenth, nineteenth, and twentieth vertebræ, in which they become rapidly shorter, and in the last appear as mere appendages to the end of the long and broad diapophyses: but the hæmapophyses by no means disappear after the solution of their union with their pleurapophyses; they are essentially independent elements of the segment, and they are continued, therefore, in pairs along the ventral surface of the abdomen of the Crocodilia, as far as their modified homotypes the pubic bones. They are more or less ossified, and are generally divided into two or three pieces.

Another character afforded by the hæmal arch is the more important in reference to palæontology, as it affects the centrum and neural arch of the vertebra as well as the pleurapophysis; and thus aids in the determination of the vertebra. The parapophysis progressively ascends upon the side of the centrum in the two anterior dorsal vertebræ, and disappears in the third, or, passing upon its neurapophysis, blends with the base of the diapophysis. In this segment, therefore, the proximal end of the rib ceases to be bifurcate, but is simply notched, the curtailed head being applied to the end of the thickened anterior part of the transverse process, and the tubercle abutting against its extremity; in the five following dorsals the head and tubercle of the rib progressively approximate and blend together, or the head disappears in the tenth dorsal, in which the rib is simply attached to the end of the diapophysis. The hypapophysis ceases to be developed after the third or fourth dorsal vertebræ. The zygapophyses become gradually more horizontal, the anterior ones looking more directly upwards, the posterior ones downwards.

The 'lumbar vertebræ' are those in which the diapophyses cease to support moveable pleurapophyses, although they are elongated by the coalesced rudiments of such which are distinct in the young *Crocodilia.* The development and persistent individuality of more or fewer of these rudimental ribs determines the number of the dorsal and lumbar vertebræ respectively, and exemplifies the purely artificial character of the distinction. The number of vertebræ or segments between the skull and the sacrum, in all the *Crocodilia* I have yet examined, is twenty-four. In the skeleton of a Gavial I have seen thirteen dorsal and two lumbar; in that of a *Crocodilus cataphractus* twelve dorsal and three lumbar; in those of a *Crocodilus acutus,* and *Alligator lucius,* eleven dorsal and four lumbar, and this is the most common number; but in

the skeleton of the Crocodile, I believe of the species called *Croc. biporcatus*, described by Cuvier,* he gives five as the number of the lumbar vertebræ. But these varieties in the development or coalescence of the stunted pleurapophysis are of little essential moment; and only serve to show the artificial character of the 'dorsal' and 'lumbar' vertebræ. The coalescence of the rib with the diapophysis obliterates of course the character of the 'costal articular surfaces;' which we have seen to be common to both dorsal and cervical vertebræ. The lumbar zygapophyses have their articular surfaces almost horizontal, and the diapophyses, if not longer, have their antero-posterior extent somewhat increased; they are much depressed, or flattened horizontally.

The sacral vertebræ are very distinctly marked by the flatness of the coadapted ends of their centrums; there are never more than two such vertebræ in the *Crocodilia* recent or extinct: in the first the anterior surface of the centrum is concave; in the second it is the posterior surface; the zygapophyses are not obliterated in either of these sacral vertebræ, so that the aspects of their articular surface—upwards in the anterior pair, downwards in the posterior pair—determines at once the corresponding extremity of a detached sacral vertebra. The thick and strong transverse processes form another characteristic of these vertebræ; for a long period the suture near their base remains to show how large a proportion is formed by the pleurapophysis. This element articulates more with the centrum than with the diapophysis developed from the neural arch; † it terminates by a rough, truncate, expanded extremity, which almost or quite joins that of the similarly but more expanded rib of the other sacral vertebræ. Against these extremities is applied a supplementary costal piece, serially homologous with the appendage to the proper pleurapophysis in the dorsal vertebræ, but here interposing itself between the pleurapophyses and hæmapophyses of both sacral vertebræ, not of one only. This intermediate pleurapophysial appendage is called the 'ilium;' it is short, thick, very broad, and subtriangular, the lower truncated apex forming with the connected extremities of the hæmapophysis an articular cavity for the diverging appendage, called the 'hind leg.' The hæmapophysis of the anterior sacral vertebra is called 'pubis;' it is moderately long and slender, but expanded and flattened at its lower extremity, which is directed forwards towards that of its fellow, and joined to it through the intermedium of a broad, cartilaginous, hæmal spine, completing the hæmal canal. The posterior hæmapophysis is broader, subdepressed, and subtriangular, expanding as it approaches its fellow to complete the second hæmal arch; it is termed 'ischium.' The great development of all the elements of these hæmal arches, and the peculiar and distinctive forms of those that have thereby acquired, from the earliest dawn of anatomical science, special names, relates phy-

* Tom. cit., p. 95. It is to be observed that Cuvier begins to count the dorsal vertebra when the rib has changed its hatchet-shape for a styloid shape.

† Cuvier, who well describes this structure, remarks, "aussi méritent-elles plutôt le nom des côtes que celui d'apophyses transverses." (Tom. cit., p. 98.)

siologically to the functions of the diverging appendage which is developed into a potent locomotive member. This limb appertains properly, as the proportion contributed by the ischium to the articular socket and the greater breadth of the pleurapophysis show, to the second sacral vertebra; to which the ilium chiefly belongs.

The first caudal vertebra, which presents a ball for articulating with a cup on the back part of the last sacral, retains, nevertheless, the typical position of the ball on the back part of the centrum; it is thus biconvex, and the only vertebra of the series which presents that structure. I have had this vertebra in three different species of extinct Eocene *Crocodilia*. In the *Crocodilus toliapicus*, Pl. 5, fig. 7; in the *Croc. champsoïdes*, Pl. 3 *A*, fig. 10; and in the *Crocodilus Hastingsiæ*, Pl. 1 *D*, fig. 7.

The advantage of possessing such definite characters for a particular vertebra is, that the homologous vertebra may be compared in different species, and may yield such distinctive characters as will be hereafter pointed out in those of the three species above cited.

The first caudal vertebra, moreover, is distinguished from the rest by having no articular surfaces for the hæmapophyses, which in the succeeding caudals form a hæmal arch, like the neurapophyses above, by articulating directly with the centrum. The arch so formed has its base not applied over the middle of a single centrum, but like the neural arch in the back of the tortoise and sacrum of the bird, across the interspace between two centrums. The first hæmal arch of the tail belongs, however, to the second caudal vertebra, but it is displaced a little backwards from its typical position.

The detached centrum of a caudal vertebra, besides being more slender and compressed, is distinguished from those of the before-described vertebræ by the two articular surfaces at the posterior border of their under surface. The zygapophyses become vertical as far as the sixteenth or seventeenth, beyond which the two posterior zygapophyses coalesce in an oblique plane notched in the middle, which is received into a wider notch at the fore part of the neural arch of the succeeding vertebra. The sutures between the pleurapophyses and diapophyses are maintained during a long period of the animal's growth, and demonstrate the share which these two elements respectively take in the formation of the transverse process. So constituted, these processes progressively decrease in length to the fifteenth or sixteenth caudal vertebra, and then disappear. The neural spines progressively decrease in every dimension, save length, which is rather increased as far as the twenty-second or twenty-third vertebra, beyond which they begin again to shorten, and finally subside in the terminal vertebræ of the tail.

The caudal hæmapophyses coalesce at their lower or distal ends, from which a spinous process is prolonged downwards and backwards; this grows shorter towards the end of the tail, but is compressed and somewhat expanded antero-posteriorly. The hæmal arch so constituted has received the name of 'chevron bone.'

A side view of the body of a middle caudal vertebra of the *Crocodilus toliapicus* is

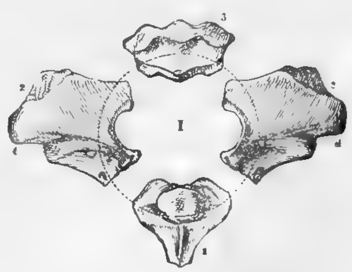
given in Pl. 3, fig. 8, and an under view of the same in fig. 9, showing the two hyp-apophysial ridges extending from the articular facets for the hæmapophyses at one end to the other end of the centrum.

The segments of the endo-skeleton composing the skull are more modified than those of the pelvis; but just as the vertebral pattern is best preserved in the neural arches of the pelvis, which are called collectively 'sacrum,' so, also, is it in the same arches of the skull, which are called collectively 'cranium.' The elements of which these cranial arches are composed preserve, moreover, their primitive or normal individuality more completely than in any of the vertebræ of the trunk, except the atlas, and consequently the archetypal character can be more completely demonstrated.

In fossil *Crocodilia,* and many other reptiles, the bones of the head are very liable from this cause to a greater extent of dislocation and separation than happens to the skull of the warm-blooded animal, in which a greater proportion of those primitive bones coalesce with age. It not unfrequently happens that detached bones of the skull of a reptile are found fossil, and the usually much modified form of these vertebral elements renders their determination difficult. In order to diminish this difficulty, I subjoin some figures of the individual bones from my work on the 'Archetype of the Vertebrate Skeleton,' with such indication of their natural connexions, as is compatible with a clear outline. A profile or side view of all the bones is offered in fig. 13, and as those of the cranium are least familiar to the palæontologist in their detached state, I have added a direct view of them nearly as they are arranged in the formation of the successive neural arches of the skull. Such figures are the more necessary in the present state of anatomy and palæontology, since the illustrations of the osteology of the crocodile which have hitherto been prefixed to the descriptions of the fossil remains of the Reptilian class, as, e. g., in the great work of Cuvier, include only figures of the bones in question as they are naturally combined together in the entire skull.

If, after separating the atlas from the occiput, we proceed to detach the occipital segment of the cranium from the next segment in advance, we find the detached segment presenting the form of the neural arch, and it is easily and naturally divisible into the four bones figured in Cut 9. The dotted circle crosses the margins at which the bones were joined together, in order to encompass the hindmost segment of the brain, called 'epencephalon,' whence this neural arch of the occiput is termed 'epencephalic arch.' No. 1 is the base of the arch, and is the 'centrum' or body of the whole occipital vertebra: it presents, like those of the trunk, a convexity or ball at its posterior articular surface, but its anterior one, like the hindmost centrum of the sacrum, unites with the next centrum in advance by a flat rough 'sutural' or 'symphysial' surface. Like most of the centrums in the

Fig. 9.



Bones of the disarticulated epencephalic arch, viewed from behind (Crocodile).

neck and beginning of the back, that of the occiput developes a 'hypapophysis,' but this descending process is longer and larger, its base extending over the whole of the under surface of the centrum. It is a character whereby the occipital centrum of a Crocodilian reptile may be distinguished from that of a Lacertian one; for in the latter a pair of diverging hypapophyses project from the under surface, as is shown in most recent lizards and in the great extinct *Mosasaurus*.*

The upper and lateral parts of no. 1 present rough sutural surfaces, like those in the centrums of the trunk, for articulating with the 'neurapophyses,' nos 2, 2, which develope short, thick, obtuse, transverse processes (4, 4). The modified or specialized character of the elements of the cranial vertebræ has gained for them special names. The centrum (1) is called the 'basioccipital;' the neurapophyses (2, 2) are the 'exoccipitals;' the neural spine (3) is the 'superoccipital.' The transverse processes (4, 4), which may combine both diapophyses and parapophyses, but which, from the modifications of the transverse processes of the atlas, and the autogenous character of the parapophyses in some fishes, and of the processes in question in the Chelonian Reptiles, I believe to be best entitled to be regarded as the parapophyses, are called the 'paroccipitals;' they are never detached bones in the Crocodilia, as they are in the Chelonia and in most fishes.

The exoccipitals perform the usual functions of neurapophyses, and, like those of the atlas, meet above the neural canal; they are perforated to give exit to the vagal and hypoglossal nerves, and protect the sides of the medulla oblongata and cerebellum —the two divisions of the epencephalon. The superoccipital (3) is broad and flat, like the similarly detached neural spine of the atlas; it advances a little forwards, beyond its sustaining neurapophyses, to protect the upper surface of the cerebellum: it is traversed by tympanic air-cells, and assists with the exoccipitals (2, 2) in the formation of the chamber for the internal ear.

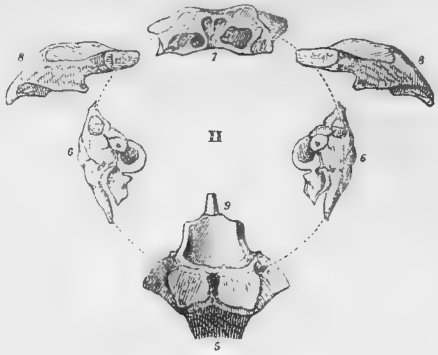
The chief modification of the occipital segment of the skull, as compared with that of the osseous fish, or with the typical vertebra, is the absence of an attached hæmal arch. We shall afterwards see that this arch is present in the Crocodile, although displaced; a profile of it is given, as restored to its typical position, in the side view of the bones of the skull, fig. 13.

Proceeding with the neural arches of the Crocodile's skull, if we dislocate the segment in advance of the occiput, we bring away in connexion with the long base-bone, 5 and 9, fig. 13, the bones which, in the same figure, are tied together by the double lines, N II, N III, and by the curved arrows, H II and H III. In fact, the centrums of two vertebræ have here coalesced, as we find to happen in the neck of the Siluroid fishes, and in the sacrum of birds and mammals. The two connate cranial centrums must be artificially divided, in order to obtain the segments distinct to which they belong. Fig. 10 gives a back view of the disarticulated bones of the neural

* See Quarterly Journal of the Geological Society, Nov. 1, 1849, p. 382, pl. x, figs. 5, 6.

arch of the 'parietal vertebra,' as the segment is termed which is in advance of the occipital one. The hinder portion (5) of the great base-bone, which is the centrum of the parietal vertebra, is called 'basisphenoid.' It supports that part of the 'mesencephalon,' which is formed by the lobe of the third ventricle, and its upper surface is excavated for the pituitary prolongation of that cavity. The basisphenoid developes from its under surface a 'hypapophysis,' which is suturally united with the fore part of that of the basioccipital, but extends further down, and is similarly united in front to the 'pterygoids' (24). These rough sutural surfaces of the long descending process of the basisphenoid are very characteristic of that centrum, when detached in a fossil state. The neurapophyses of the parietal vertebra (6, 6) are called the 'alisphenoids;'* they protect the sides of the mesencephalon, and are notched at their anterior margin, for a conjugational foramen transmitting the trigeminal nerve. As accessory functions they contribute, like the corresponding bones in fishes, to the formation of the ear-chamber. They have, however, a little retrograded in position (see fig. 14, 6), resting below, in part upon the occipital centrum, and supporting more of the spine of that segment (3) than of their own (7). The spine of the parietal vertebra (fig. 10, 7) is a permanently distinct, single, depressed bone, like that of the occipital vertebra; it is called the 'parietal,' and completes the neural arch, as its crown or key-bone; it is partially excavated by the tympanic air-cells. The bones 8, 8 wedged between 6 and 7, manifest more of their parapophysial character than their homotypes (4, 4) do in the occipital segment, since they support modified ribs, are developed from independent centres, and preserve their individuality. They form no part of the inner walls of the cranium, but send outwards and backwards a strong transverse process for muscular attachment. They afford a ligamentous attachment to the hæmal arch (fig. 13, H II) of their own segment, and articulate largely with the pleurapophysis (28) of the antecedent hæmal arch (H III), whose more backward displacement, in comparison with its position in the fish's skull, is well illustrated in the metamorphosis of the toad and frog.

Fig. 10.



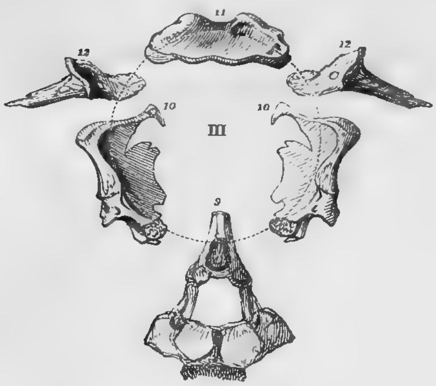
Disarticulated mesencephalic arch, viewed from behind (Crocodile).

On removing the neural arch of the parietal vertebra, after the section of its confluent centrum, the elements of the corresponding arch of the frontal vertebra, slightly disarticulated, present the arrangement shown in fig. 11. The compressed produced centrum (9) shown in natural connexion with the parietal centrum 5 in fig. 13,

* This bone is the 'rocher' or petrous portion of the temporal bone, according to Cuvier, in the Reptiles (Ossemens Fossiles, v, pt. ii, 1824); but is the 'aile temporale du sphénoïde' in fishes (Histoire Naturelle des Poissons, tom. i, 1828), birds, and mammals.

and with the bone 10 in fig. 14, has its form modified like that of the vertebral centrums at the opposite extreme of the body in many birds; it is called the 'presphenoid.'

Fig. 11.



Disarticulated prosencephalic arch, viewed from behind (Crocodile).

The neurapophyses 10, 10, articulate with the upper part of 9; they are expanded and smoothly excavated on their inner surface to support the sides of the large prosencephalon; they dismiss the great optic nerves by the notch marked *op* in fig. 14, and the motor nerves of the eyeball by the notch *s*. They show the same tendency to a retrograde change of position, as the neighbouring neurapophyses (6); for though they support a greater proportion of their proper spine (11), they also support part of the parietal spine (7), and rest, in part, below upon the parietal centrum (5): the neurapophyses (10, 10) are called 'orbitosphenoids.'* The neural spine (11) of the frontal vertebra retains its normal character as a single symmetrical bone, like the parietal spine which it partly overlaps; it also completes the neural arch of its own segment, but is remarkably extended longitudinally forwards, as is shown in figs. 13 and 14, 11, where it is much thickened, and assists in forming the cavities for the eyeballs (*or*, fig. 14): it is called the (frontal) bone.

In contemplating in the skull itself, or in such side views as are given in figs. 13 and 14, the relative position of the frontal (11), to the parietal (7), and of this to the superoccipital (3), which is overlapped by the parietal, just as itself overlaps the flattened spine of the atlas, we gain a conviction which cannot be shaken by any difference in their mode of ossification, by their median bipartition, or by their extreme expansion in other animals, that the above-named single, median, imbricated bones, each completing its neural arch, and permanently distinct from the piers of such arch, must repeat the same element in those successive arches, in other words, must be 'homotypes,' or serially homologous.† In like manner the serial homology of those piers, called 'neurapophyses,' viz. the laminæ of the atlas (fig. 8 *na*), the exoccipitals (figs. 13 and 14, 2), the alisphenoids (6), and the orbitosphenoids (10), is equally unmistakable. Nor can we shut out of view the same serial relationship of the paroccipitals (4), as coalesced parapophyses of the occipital vertebra, with the mastoids (8), and the postfrontals (12), as permanently detached parapophyses of their respective vertebræ. All stand out from the sides of the cranium, as transverse processes for muscular attachment, all are alike autogenous in the Chelonians, and all of them, in fishes, offer articular surfaces

* According to Cuvier, this bone is the 'aile temporale du sphénoïde et une grande partie de l'aile orbitaire' in Crocodiles. (Ossemens Fossiles, tom. v, pt. ii.)

† See my work 'On the Archetype of the Vertebrate Skeleton,' pp. 5-8, 8vo, Van Voorst, for the explanation of these terms.

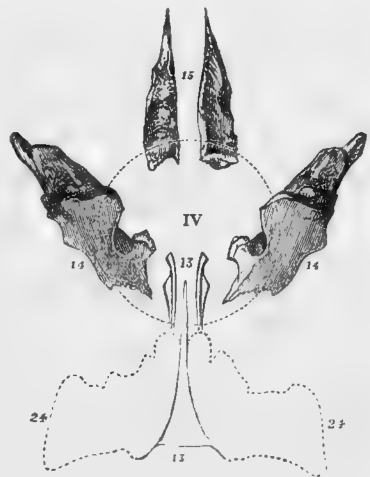
for the ribs or hæmal arches of their respective vertebræ; and these characters are retained in the postfrontals as well as in the mastoids of the Crocodiles.

The frontal parapophysis (12, fig. 11) is wedged between the back part of the spine (11) and the neurapophysis (10); its outwardly projecting process extends also backwards and joins that of the succeeding parapophysis (8); but, notwithstanding the retrogradation of the inferior arch (fig. 13, H III), it still articulates with part of its own pleurapophysial element (28), which forms the proximal element of that arch.

There finally remain in the cranium* of the Crocodile, after the successive detachment of the foregoing arches, the bones intersected by the double line N IV, in fig. 13, which, as in fig. 14, are numbered 13, 14, and 15, and of which a foreshortened back view is represented in Cut 12; but, notwithstanding the extreme degree of modification to which their extreme position subjects them, we can still trace in their arrangement a correspondence with the vertebrate type.

A long and slender symmetrical grooved bone (13, between 24, 24), like the ossified inferior half of the capsule of the notochord, is continued forwards from the inferior part of the centrum (9) of the frontal vertebra, and stands in the relation of a centrum to the vertical plates of bone (14), fig. 12, and fig. 14, which expand as they rise into a broad, thick, triangular plate, with an exposed horizontal superior surface. These bones, which are called 'prefrontals,' stand in the relation of 'neurapophyses' to the rhinencephalic prolongations of the brain, commonly but erroneously called 'olfactory nerves;' and they form the piers or haunches of a neural arch, which is completed above by a pair of symmetrical bones (15) called 'nasals,' which I regard as a divided or bifid neural spine.

Fig. 12.



Disarticulated rhinencephalic arch, with the anchylosed pterygoids (24) in dotted outline (Crocodile).

The centrum of this arch is established by ossification in the expanded anterior prolongation of the fibrous capsule of the notochord, beyond the termination of its gelatinous axis. The

* The part called cranium in human anatomy is a quite artificial division of the skull; it includes the neurapophyses of the nasal vertebræ, coalesced with the capsules of the sense of smell, and excludes the centrum and neural arch of the same natural segment; it also includes one portion of the diverging appendage (27) of the maxillary arch, because it enters largely into the formation of the capacious cranial cavity of man, and another portion of the diverging appendage of the same arch (24), because it happens to coalesce with the basisphenoid. The capsule of the organ of hearing is included together with part of that of the olfactory organ, whilst the capsule of the organ of sight, and part of that of the organ of smell are excluded. None of these sense-capsules properly form any part of the cranium, but they are lodged in interspaces of its constituent arches. The cranial portion of the skull, as a natural division of that part of the endoskeleton, ought to consist exclusively of the neural arches and centrums of the cranial vertebræ.

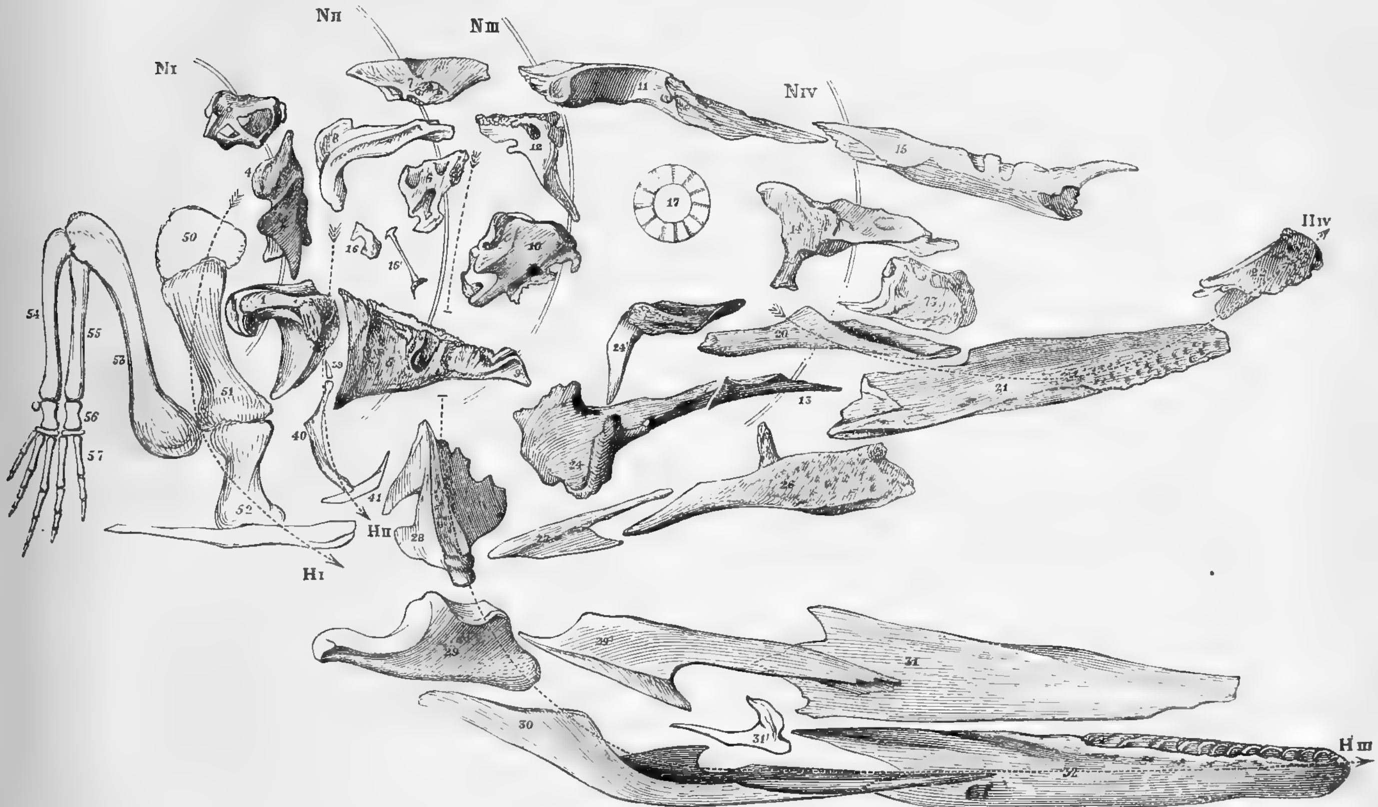
median portion above specified retains most of the formal characters of the centrum, but there is a pair of long, slender, symmetrical ossicles, which, from the seat of their original development, and their relative position to the neural arch, must be regarded as also parts of its centrum. And this ossification of the element in question from different centres will be no new or strange character to those who recollect that the vertebral body in man and mammalia is developed from three centres. The term 'vomer' is applied to the pair of bones 13, in fig. 12, because their special homology with the single median bone, so called in fishes and mammals, is indisputable; but a portion of the same element of the skull retains its single symmetrical character in the Crocodile, and is connate with the enormous pterygoids (24), between which it is wedged. In some Alligators (*All. niger*) the divided anterior vomer extends far forwards, expands anteriorly, and appears upon the bony palate.

Almost all the other bones of the head of the Crocodile are adjusted so as to constitute four inverted arches, respectively completed or closed below at the points marked H IV, H III, H II, and H I, in fig. 13. These are the hæmal arches of the four segments or vertebræ, of which the neural arches have been just described. But they have been the seat of much greater modifications, by which they are made subservient to a variety of functions unknown in the hæmal arches of the rest of the body. Thus the two anterior hæmal arches of the head perform the office of seizing and bruising the food; are armed for that purpose with teeth: and, whilst one arch is firmly fixed, the other works upon it like the hammer upon the anvil. The elements of the fixed arch (H IV), called 'maxillary arch,' have accordingly undergone the greatest amount of morphological change in order to adapt that arch to its share in mastication, as well as for forming part of the passage for the respiratory medium, which is perpetually traversing this hæmal canal in its way to purify the blood. Almost the whole of the upper surface of the maxillary arch is firmly united to contiguous parts of the skull by rough or sutural surfaces, and its strength is increased by bony appendages, which diverge from it to abut against other parts of the skull. Comparative anatomy teaches that, of the numerous places of attachment, the one which connects the maxillary arch by its element (20) with the centrum (13) and the descending plates of the neurapophyses (14) of the nasal segment, is the normal or the most constant point of its suspension, the bone (20) being the pleurapophysial element of the maxillary arch: it is called the 'palatine,' because the under surface, shown in Pl. *A*, 2, and Pl. 1 *B*, at 20, forms a portion of the bony roof of the mouth called the 'palate.'

It is articulated at its fore part with the bone (21) in the same plates, which bone is the hæmapophysial element of the maxillary arch. It is called the 'maxillary,' and is greatly developed both in length and breadth; it is connected not only with 20 behind, and 22 in front, which are parts of the same arch (see fig. 13), and with the diverging appendages of the arch, viz. (26) the malar bone, and (24) the pterygoid, but also with the nasals (15) and the lachrymal (16), as well as with its fellow of the

opposite side of the arch. The smooth expanded horizontal plate which effects the latter junction, shown in Pl. 1 *B*, and Pl. *A* 2, at 21, is called the palatal plate of the maxillary; the thickened external border, where this plate meets the external rough surface of the bone, and which is perforated for the lodgement of the teeth, is the 'alveolar border' or 'process' of the maxillary. The hæmal spine or key-bone of the arch (22) is bifid, and the arch is completed by the symphysial junction of the two symmetrical halves at H IV, fig. 13; these halves are called 'premaxillary bones;'

Fig. 13.



Disarticulated bones of the Skull of an Alligator, N I to IV the neural arches; H I to IV the hæmal arches and appendages.

these bones, like the maxillaries, have a rough facial plate, Pl. 1 *A*, 22 and a smooth palatal plate Pl. 1 *B*, 22, with the connecting alveolar border. The median symphysis is perforated vertically through both plates; the outer or upper hole being the external nostril, the under or palatal one being the prepalatal or naso-palatal aperture; this is completely inclosed by the premaxillary bone, as shown in Pl. 1 *B*, fig. 2, 22, and Pl. 1 *C*, 22, *np*; whilst, in all known existing Crocodiles and Alligators, the tips of the nasal bones, as at 15, fig. 1, Pl. *A* 2, enter into the back part of the circumference of the nasal aperture. In the Gavials, as may be seen in Pl. 1, fig. 1 *a*, the nasal aperture is wholly surrounded by the premaxillaries, *i*; and one of the fossil Eocene Crocodiles,

presently to be described, Pl. 1 *A*, fig. 1, differs from all the modern species, in the exclusion of the nasal bones (13) from the nasal aperture.

Both the palatine (fig. 13, 20) and the maxillary (ib. 21) send outwards and backwards, parts or processes which diverge from the line of the hæmal arch of which they are the chief elements; and these parts give attachment to distinct bones which form the 'diverging appendages' of the arch, and serve to attach it, as do the diverging appendages of the thoracic hæmal arches in the bird, to the succeeding arch.

The appendage (24) called 'pterygoid' effects a more extensive attachment, and is peculiarly developed in the *Crocodilia*. As it extends backwards it expands, unites with its fellow, below the nasal canal, and encompassing that canal, coalesces above it with the vomer, and is firmly attached by suture to the presphenoid and basisphenoid: it surrounds the hinder or palatal nostril, and, extending outwards, as shown in Pl. 1 *A*, fig. 3 (24), it gives attachment to a second bone (25), called 'ectopterygoid,' which is firmly connected with the maxillary (25), the malar (26), and the post-frontal (12). The second diverging ray is of great strength; it extends from the maxillary (21) ('hæmapophysis' of the maxillary arch) to the tympanic (28) ('pleurapophyses' of the mandibular arch), and is divided into two pieces, the malar (26), and the squamosal (27). Such are the chief Crocodilian modifications of the hæmal arch and appendages of the anterior or nasal vertebra of the skull.

The hæmal arch of the frontal vertebra is somewhat less metamorphosed, and has no diverging appendage. It is slightly displaced backwards, and is articulated by only a small proportion of its pleurapophysis (28), to the parapophysis (12) of its own segment; the major part of that short and strong rib articulating with the parapophysis (8) of the succeeding segment. The bone (28) called 'tympanic,' because it serves to support the 'drum of the ear,' in air-breathing vertebrates, is short, strong, and immoveably wedged, in the *Crocodilia*, between the paroccipital (4), mastoid (8), post-frontal (12), and squamosal (27); and the conditions of this fixation of the pleurapophysis are exemplified in the great development of the hæmapophysis (mandible), which is here unusually long, supports numerous teeth, and requires, therefore, a firm point of suspension, in the violent actions to which the jaws are put in retaining and overcoming the struggles of a powerful living prey. The moveable articulation between the pleurapophysis (28) and the rest of the hæmal arch is analogous to that which we find between the thoracic pleurapophysis and hæmapophysis in the Ostrich and many other birds. But the hæmapophysis of the mandibular arch in the Crocodiles is subdivided into several pieces, in order to combine the greatest elasticity and strength with a not excessive weight of bone. The different pieces of this purposely subdivided element have received definite names. That numbered 29, which offers the articular concavity to the convex condyle of the tympanic (28), is called the 'articular' piece; that beneath it (30), which developes the angle of the jaw, when this projects, is the 'angular' piece; the piece above (29′) is the 'surangular;' the thin, broad, flat

piece (31), applied, like a splint, to the inner side of the other parts of the mandible, is the 'splenial;' the small accessory ossicle (31′) is the 'coronoid,' because it developes the process so called, in lizards; the anterior piece (32), which supports the teeth, is called the 'dentary.' This latter is the homotype of the premaxillary, or it represents that bone in the mandibular arch, of which it may be regarded as the hæmal spine; the other pieces are subdivisions of the hæmapophysial element. The purport of this subdivision of the lower jaw-bone has been well explained by Conybeare* and Buckland,† by the analogy of its structure to that adopted in binding together several parallel plates of elastic wood or steel to make a crossbow, and also in setting together thin plates of steel in the springs of carriages. Dr. Buckland adds, "those who have witnessed the shock given to the head of a Crocodile by the act of snapping together its thin long jaws, must have seen how liable to fracture the lower jaw would be, were it composed of one bone only on each side." The same reasoning applies to the composite structure of the long tympanic pedicle in fishes. In each case the splicing and bracing together of thin flat bones of unequal length and of varying thickness, affords compensation for the weakness and risk of fracture that would otherwise have attended the elongation of the parts. In the abdomen of the Crocodile the analogous subdivision of the hæmapophyses, there called abdominal ribs, allows of a slight change of their length, in the expansion and contraction of the walls of that cavity; and since amphibious reptiles, when on land, rest the whole weight of the abdomen directly upon the ground, the necessity of the modification for diminished liability to fracture further appears. These analogies are important, as demonstrating that the general homology of the elements of a natural segment of the skeleton is not affected or obscured by their subdivision for a special end. Now this purposive modification of the hæmapophyses of the frontal vertebra is but a repetition of that which affects the same elements in the abdominal vertebræ.

Passing next to the hæmal arch of the parietal vertebra (fig. 13, H III), we are first struck by its small relative size; its restricted functions have not required it to grow in proportion with the other arches, and it consequently retains much of its embryonic dimensions. It consists of a ligamentous 'stylohyal'—its pleurapophysis, retaining the same primitive histological condition which obstructs the ordinary recognition of the same elements of the lumbar hæmal arches. A cartilaginous 'epihyal' (39) intervenes between this and the ossified 'hæmapophysis' (40), which bears the special name of ceratohyal. The hæmal spine (41) retains its cartilaginous state, like its homotypes in the abdomen: there they get the special name of 'abdominal sternum,' here of 'basihyal.' The basihyal has, however, coalesced with the thyrohyals, to form a broad cartilaginous plate, the anterior border rising like a valve to close the fauces, and the posterior angles extending beyond and sustaining the thyroid and other parts of the

* Geol. Trans., 1821, p. 565.

† Bridgewater Treatise, 1836, vol. i, p. 176.

larynx. The long bony 'ceratohyal' (fig. 13, 40), and the commonly cartilaginous 'epihyal' (ib. 39), are suspended by the ligamentous 'stylohyal' to the paroccipital process; the whole arch having, like the mandibular one, retrograded from the connexion it presents in fishes.

This retrogradation is still more considerable in the succeeding hæmal arch. In comparing the occipital segment of the crocodile's skeleton with that of the fish, the chief modification that distinguishes that segment in the crocodile is the apparent absence of its hæmal arch. We recognise, however, the special homologues of the constituents of that arch of the fishes' skeleton in the bones 51 and 52 of the crocodile's skeleton (fig. 13); but the upper or suprascapular piece (50) retains, in connexion with the loss of its proximal or cranial articulations, its cartilaginous state: the scapula (51) is ossified, as is likewise the coracoid (52), the lower end of which is separated from its fellow by the interposition of a median, symmetrical, partially ossified piece called 'episternum' (H I). The power of recognising the special homologies of 50, 51, and 52 in the crocodile, with the similarly numbered constituents of the same arch in fishes*, though masked, not only by modifications of form and proportion, but even of very substance, as in the case of 50, depends upon the circumstance of these bones constituting the same essential element of the archetypal skeleton; for although in the present instance there is superadded to the adaptive modifications above cited, the rarer one of altered connexions, Cuvier does not hesitate to give the same names, 'suprascapulaire' to 50 and 'scapulaire' to 51, in both fish and crocodile: but he did not perceive or admit that the narrower relations of special homology were a result of, and necessarily included in, the wider law of general homology. According to the latter, we discern in 50 and 51 a teleologically compound 'pleurapophysis,' in 52 a 'hæmapophysis,' and in *hs* the 'hæmal spine,' completing the hæmal arch.

The general relations of the scapulo-coracoid arch to a hæmal or costal one was early recognised by Oken. This philosopher, having observed the free cervical ribs in a specimen of the *Lacerta apoda*, Pallas (*Pseudopus*), deemed them representatives of the scapula, and this bone to be, in other animals, the coalesced homologues of the cervical pleurapophyses.† In no animal are the conditions for testing this question so favorable and obvious as in the crocodiles and gavials (Pl. 1): not only do cervical ribs coexist with the scapulo-coracoid arch, but they are of unusual length, and are developed from the atlas as well as from each succeeding cervical vertebra: we can also trace them beyond the thorax to the sacrum, and throughout a great part of the caudal region, as the sutures of the apparently long transverse processes of the

* See fig. 5, p. 18, and pl. ii, fig. 2, in 'The Archetype and Homologies of the Vertebrate Skeleton.'

† "Auch die Scapula nicht *ein* Knochen, sondern wenigstens eine aus fünf Halsrippen zusammengeflossene Platte ist."—*Programm über die Bedeutung der Schädelknochen*, 4to, 1807, p. 16. He reproduces the same idea of the general homology of the scapula in the '*Lehrbuch der Natur-philosophie*,' 1843, p. 331, ¶ 2381. Carus also regards the scapulo-coracoid arch as the reunion of several (at least three) proto-vertebral arches of the trunk-segments. (*Urtheilen des Knochen und Schalen gerustes*, fol., 1828.)

coccygeal vertebræ demonstrate in the young animal; the lumbar pleurapophyses being manifested at the same period as cartilaginous appendages to the ends of the long diapophyses.

The scapulo-coracoid arch, both elements (51, 52) of which retain the form of strong and thick vertebral and sternal ribs in the crocodile, is applied in the skeleton of that animal over the anterior thoracic hæmal arches. Viewed as a more robust hæmal arch, it is obviously out of place in reference to the rest of its vertebral segment. If we seek to determine that segment by the mode in which we restore to their centrums the less displaced neural arches of the antecedent vertebræ of the cranium or in the sacrum of the bird,* we proceed to examine the vertebræ before and behind the displaced arch, with the view to discover the one which needs it, in order to be made typically complete. Finding no centrum and neural arch without its pleurapophyses from the scapula to the pelvis, we give up our search in that direction; and in the opposite direction we find no vertebra without its ribs until we reach the occiput: there we have centrum and neural arch, with coalesced parapophyses—the elements answering to those included in the arch N I, fig. 13—but without the arch H I; which arch can only be supplied, without destroying the typical completeness of antecedent cranial segments, by a restoration of the bones 50—52, to the place which they naturally occupy in the skeleton of the fish. And since anatomists are generally agreed to regard the bones 50—52 in the crocodile (fig. 13) as specially homologous with those so numbered in the fish,† we must conclude that they are likewise homologous in a higher sense; that in the fish, the scapulo-coracoid arch is in its natural or typical position, whereas in the crocodile it has been displaced for a special purpose. Thus, agreeably with a general principle, we perceive that, as the lower vertebrate animal illustrates the closer adhesion to the archetype by the natural articulation of the scapulo-coracoid arch to the occiput, so the higher vertebrate manifests the superior influence of the antagonising power of adaptive modification by the removal of that arch from its proper segment.

The anthropotomist, by his mode of counting and defining the dorsal vertebræ and ribs, admits, unconsciously perhaps, the important principle in general homology which is here exemplified, and which, pursued to its legitimate consequences and further applied, demonstrates that the scapula is the modified rib of that centrum and neural arch which he calls the 'occipital bone,' and that the change of place which chiefly masks that relation (for a very elementary acquaintance with comparative anatomy shows how little mere form and proportion affect the homological characters of bones) differs only in extent and not in kind from the modification which makes a minor amount of comparative observation requisite, in order to determine the relation of the shifted dorsal rib to its proper centrum in the human skeleton.

* See 'On the Archetype and Homologies of the Vertebrate Skeleton,' p. 117, p. 159.

† Op. cit., fig. 5, p. 17.

With reference, therefore, to the occipital vertebra of the crocodile, if the comparatively well-developed and permanently distinct ribs of all the cervical vertebræ prove the scapular arch to belong to none of those segments, and, if that hæmal arch be required to complete the occipital segment, which it actually does complete in fishes, then the same conclusion must apply to the same arch in other animals, and we must regard the occipital vertebra of the tortoise as completed below by its scapulo-coracoid arch and not, as Bojanus supposed, by its hyoidean arch.*

Having thus endeavoured to show what the scapular arch of the crocodile is, I proceed to point out the characteristic form of its chief elements. The upper and principal part of the scapula (51, fig. 13) is flattened, and gradually becomes narrower to the part called its neck, which is rounded, bent inwards, and then suddenly expanded to form a rough articular surface for the coracoid, and a portion of a smoother surface for the shoulder-joint. The contiguous end of the coracoid (52) presents a similar form, having not only the rough surface for its junction with the scapula, but contributing, also, one half of the cavity for the head of the humerus. It is perforated near the interspace between these two surfaces. As it recedes from them, it contracts, then expands and becomes flattened, terminating in a somewhat broader margin than the base of the scapula, which margin is morticed into a groove at the anterior border of the broad rhomboidal cartilage continued beyond the ossified part of the manubrium, which forms the key-bone of the scapular arch. The anterior locomotive extremity is the diverging appendage of the arch, under one of its numerous modes and grades of development.†

The proximal element of this appendage or that nearest the arch, is called the 'humerus' (53, fig. 13): its head is subcompressed and convex; its shaft bent in two directions, with a deltoid crest developed from its upper and fore part; its distal end is transversely extended, and divided anteriorly into two condyles. The shaft of this bone has a medullary cavity, but relatively smaller than in the mammalian humerus.

The second segment of the limb consists of two bones: the larger one (54) is called the 'ulna:' it articulates with the outer condyle of the humerus by an oval facet, the

* Anatome Testudinis Europæa, fol., 1819, p. 44. Geoffroy St. Hilaire selected the opercular and sub-opercular bones to form the inverted arch of his seventh (occipital) cranial vertebra, and took no account of the instructive natural connexions and relative position of the hyoidean and scapular arches in fishes. With regard to the scapular arch, he alludes to its articulation with the skull in the lowest of the vertebrate classes as an 'amalgame inattendue' (*Anatomie Philosophique*, p. 481): and elsewhere describes it as a "disposition véritablement très singulière, et que le manque absolu du cou et une combinaison des pièces du sternum avec celles de la tête pouvoient seules rendre possible."—*Annales du Muséum*, ix, p. 361. A due appreciation of the law of vegetative uniformity or repetition, and of the ratio of its prevalence and power to the grade of organization of the species, was, perhaps, essential in order to discern the true signification of the connexion of the scapular arch in fishes.

† See my Discourse 'On the Nature of Limbs,' 8vo, Van Voorst, 1849, pp. 64-70.

thick convex border of which swells a little out behind, and forms a kind of rudimental 'olecranon;' the shaft of the ulna is compressed transversely, and curves slightly outwards; the distal end is much less than the proximal one, and is most produced at the radial side.

The radius (55) has an oval head; its shaft is cylindrical; its distal end oblong and subcompressed.

The small bones (56) which intervene between these and the row of five longer bones, are called 'carpals:' they are four in number in the Crocodilia. One seems to be a continuation of the radius, another of the ulna; these two are the principal carpals; they are compressed in the middle and expanded at their two extremities; that on the radial side of the wrist is the largest. A third small ossicle projects slightly backwards from the proximal end of the ulnar metacarpal: it answers to the bone called 'pisiforme' in the human wrist. The fourth ossicle is interposed between the ulnar carpal and the metacarpals of the three ulnar digits.

These five terminal jointed rays of the appendage are counted from the radial to the ulnar side, and have received special names: the first is called 'pollex,' the second 'index,' the third 'medius,' the fourth 'annularis,' and the fifth 'minimus.' The first joint of each digit is called 'metacarpal;' the others are termed 'phalanx.' In the Crocodilia the pollex has two phalanges, the index three, the medius four, the annularis four, and the minimus three. The terminal phalanges, which are modified to support claws, are called 'ungual' phalanges.

As the above-described bones of the scapular extremity are developments of the appendage of the scapular arch, which is the hæmal arch of the occipital vertebra, it follows, that, like the branchiostegal rays and opercular bones in fishes, they are essentially bones of the head.

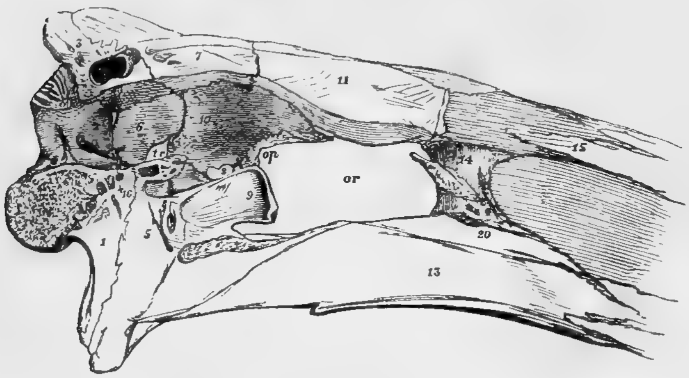
But the enumeration of the bones of the crocodile's skull is not completed by these: there is a bone anterior to the orbit, marked 73 in fig. 13, and in Pl. 1 *A* and *A* 2; it is perforated at its orbital border by the duct of the lachrymal gland, whence it is termed the 'lachrymal bone,' and its facial part extends forwards between the bones marked 14, 15, 21, and 26. In many Crocodilia there is a bone at the upper border of the orbit, which extends into the substance of the upper eyelid; it is called 'superorbital.' In the *Crocodilus palpebrosus* there are two of these ossicles.

Both the lachrymal and superorbital bones answer to a series of bones found commonly in fishes, and called 'suborbitals' and 'superorbitals.' The lachrymal is the most anterior of the suborbital series, and is the largest in fishes; it is also the most constant in the vertebrate series, and is grooved or perforated by a mucous duct. These ossicles appertain to the dermal or muco-dermal system or 'exoskeleton;' not to the vertebral system or 'endoskeleton.'

The little slender bone, marked 16′ in fig. 13, has one of its extremities in the form of a long, narrow, elliptic plate, which is applied to the 'fenestra ovalis' of the internal

ear; from this plate extends a long and slender bony stem, which grows somewhat cartilaginous, expands and bends down, as it approaches the tympanum or ear-drum, to which it is attached. The cartilaginous capsule of the labyrinth or internal ear is partially ossified by sinuous plates of bone connate with the neurapophyses (2 and 6), between which that organ is lodged; I apply the term 'petrosal' to the principal and most independent of those ossifications of the ear-capsule, to that, e. g., which retains some mobility after it has contracted a partial anchylosis to the exoccipital (2), and which appears upon the inner surface of the cranial walls at the part marked 16 in the subjoined Cut 14, between 2 and 6. It is the only independent bone on that surface of the cranium which, in my opinion, answers to the 'petrous portion of the temporal' in human anatomy, and to which the term 'rocher' can be properly applied, in the language of the French comparative anatomists. Cuvier, however, restricts that name to the 'alisphenoid' (6, figs. 13, 14) in the Crocodiles.

Fig. 14.



Vertical longitudinal section of the cranium of a Crocodile (*Crocodilus acutus*).

The ossicles, (16 and 16′), together with the partial ossifications in the sclerotic capsule of the organ of sight, (17, fig. 13)—always more distinct in *Chelonia* than in *Crocodilia*— belong to that category of visceral bones to which the term 'splanchno-skeleton' has been given; they also are foreign to the true vertebrate system of the skeleton.

Thus the classification of the bones of the head of the Crocodiles, as of all other vertebrate animals, is primarily into those of

The Endo-skeleton,
The Splanchno-skeleton, and
The Exo-skeleton.

The bones of the *endo-skeleton* of the head form naturally four segments, called

Occipital vertebra, N I, H I;
Parietal vertebra, N II, H II;
Frontal vertebra, N III, H III;
Nasal vertebra, N IV, H IV.
} Fig. 13.

These segments are subdivided into the neural arches, called

Epencephalic arch (1 basioccipital, 2 exoccipital, 3 superoccipital, 4 connate paroccipital);

Mesencephalic arch (5 basisphenoid, 6 alisphenoid, 7 parietal, 8 mastoid);

Prosencephalic arch (9 presphenoid, 10 orbitosphenoid, 11 frontal, 12 post-frontal);

Rhinencephalic arch (13 vomer, 14 prefrontal, 15 nasal):

and into the hæmal arches and their appendages, called

Maxillary arch (20 palatine, 21 maxillary, 22 premaxillary) and appendages (24 pterygoid, 24′ ectopterygoid, 26 malar, 27 squamosal);

Mandibular arch (28 tympanic, 29—32 mandible);

Hyoidean arch (39 epihyal, 40 ceratohyal, 41 basihyal);

Scapular arch (50 suprascapula, 51 scapula, 52 coracoid) and appendages (53—58 bones of fore-limb).

The bones of the *splanchno-skeleton*, are

The petrosal (16) and otosteals (16′);

The sclerotals (17) which in most retain their primitive histological condition as fibrous membrane.

The turbinals (18 and 19) and teeth.

The bones of the *exo-skeleton*, are

The lacrymals (73).

The superorbitals (present in *Alligator sclerops*).

There remains to complete this preliminary sketch of the osteology of the Crocodile a brief notice of the bones composing the diverging appendage of the pelvic arch: these being a repetition of the same element as the appendage of the scapular arch modified and developed for a similar office, manifest a very close resemblance to it. The first bone, called the 'femur,' is longer than the humerus, and, like it, presents an enlargement of both extremities, with a double curvature of the intervening shaft, but the directions are the reverse of those of the humerus, as may be seen in Pl. 1, where the upper or proximal half of the femur is concave, and the distal half convex, anteriorly. The head of the femur is compressed from side to side, not from before backwards as in the humerus; a pyramidal protuberance from the inner surface of its upper fourth represents a 'trochanter;' the distal end is expanded transversely, and divided at its back part into two condyles.

The next segment of the hind-limb or 'leg,' includes, like the corresponding segment of the fore-limb called 'fore-arm,' two bones. The largest of these is the 'tibia,' and answers to the radius. It presents a large, triangular head to the femur; it terminates below by an oblique crescent with a convex surface.

The 'fibula' is much compressed above; its shaft is slender and cylindrical, its lower end is enlarged and triangular.

All these long bones have a narrow medullary cavity.

The group of small bones which succeed those of the leg, are the tarsals; they are four in number, and have each a special name. The 'astragalus' articulates with the tibia, and supports the first and part of the second toe. It is figured in Cuvier's

'Ossemen's Fossiles,' tom. v, pt. ii, pl. iv, figs. 19 *A, B, C, D.* The 'calcaneum' intervenes between the fibula and the ossicle supporting the two outer toes; it has a short but strong posterior tuberosity.

The ossicle referred to represents the bone called 'cuboid' in the human tarsus. A smaller ossicle, wedged between the astralagus and the metatarsals of the second and third toes is the 'ectocuneiform.'

Four toes only are normally developed in the hind-foot of the *Crocodilia;* the fifth is represented by a stunted rudiment of its metatarsal, which is articulated to the cuboid and to the base of the fourth metatarsal.

The four normal metatarsals are much longer than the corresponding metacarpals. That of the first or innermost toe is the shortest and strongest; it supports two phalanges. The other three metatarsals are of nearly equal length, but progressively diminish in thickness from the second to the fourth. The second metatarsal supports three phalanges; the third four; and the fourth also has four phalanges, but does not support a claw. The fifth digit is represented by a rudiment of its metatarsal in the form of a flattened triangular plate of bone, attached to the outer side of the cuboid, and slightly curved at its pointed and prominent end.

The teeth.—The most readily recognisable character by which the existing Crocodilians are classified and grouped in appropriate genera, are derived from modifications of the dental system.

In the Caimans (genus *Alligator*) the teeth vary in number from $\frac{18-18}{18-18}$ to $\frac{22-22}{22-22}$: the fourth tooth of the lower jaw is *received into a cavity* of the alveolar surface of the upper jaw, where it is concealed when the mouth is shut. In Pl. 1 *C*, fig. 2, these pits are shown behind the last premaxillary tooth *e*, in an eocene Alligator from Hordwell. In old individuals of the existing species of Alligator, the upper jaw is perforated by the large inferior teeth in question, and the fossæ are converted into foramina.

In the Crocodiles (genus *Crocodilus*) the fourth tooth in the lower jaw is *received into a notch* excavated in the side of the alveolar border of the upper jaw, as in fig. 1, Pl. 1 *C*, behind the tooth *e*, and is visible externally when the mouth is closed, as in Pl. 1 *B*, fig. 1. In most Crocodiles, also, the first tooth in the lower jaw perforates the premaxillary bone when the mouth is closed, as in Pl. *A* 2, between the teeth marked *a* and *b*.

In the two preceding genera the alveolar borders of the jaw have an uneven or wavy contour, and the teeth are of an unequal size.

In the Gavials, (genus *Gavialis*) the teeth are nearly equal in size and similar in form in both jaws, and the first as well as the fourth tooth in the lower jaw, passes into a groove in the margin of the upper jaw when the mouth is closed, Pl. 1.

In the Alligators and Crocodiles the teeth are more unequal in size, and less regular

in arrangement, and more diversified in form than in the Gavials: witness the strong thick conical laniary teeth at the fore part of the jaw, as shown in Pl. 2 *A*, figs. 3 and 6, as contrasted with the blunt mammillate summits of the posterior teeth, as shown in Pl. 3 *A*, fig. 12. The teeth of the Gavial are subequal, most of them are long, slender, pointed, subcompressed from before backwards, with a trenchant edge on the right and left sides, between which a few faint longitudinal ridges traverse the basal part of the enamelled crown.

The teeth of both the existing and extinct Crocodilian reptiles consist of a body of compact dentine forming a crown covered by a coat of enamel, and a root invested by a moderately thick layer of cement. The root slightly enlarges, or maintains the same breadth to its base, which is deeply excavated by a conical pulp-cavity extending into the crown, and is commonly either perforated or notched at its concave or inner side.

The dentinal tubes in the crown of a fully-developed tooth form short curvatures at their commencement at the surface of the pulp-cavity, and then proceed nearly straight to the periphery of the crown; they very soon bifurcate, the divisions slightly diverging; then continuing their course with gentle parallel undulations, they subdivide near the enamel, and terminate in fine and irregular branches, which anastomose generally by the medium of cells. The dentinal tubes send off from both sides, throughout their progress, minute branches into the intervening substance, and terminate in the dentinal cells. These cells are subhexagonal, about $\frac{1}{800}$ of an inch in diameter, and are traversed by from ten to fourteen of the dentinal tubes; they are usually arranged in planes parallel with the periphery of the crown, near which they are most conspicuous, and towards which their best defined outline is directed: they combine with the parallel curvatures of the dentinal tubes to form the striæ, visible in sections of the teeth by the naked eye, which cause the stratified appearance of the dentine as if it were composed of a succession of superimposed cones. The diameter of the dentinal tube before the first bifurcation is $\frac{1}{12000}$th of an inch, both the trunks and bifurcations of the tubes have interspaces equal to four of their respective diameters.

The enamel viewed in a transverse section of the crown presents some delicate striæ parallel with its surface, whilst the appearance of fibres vertical to that surface is only to be detected, and these faintly, on the fractured edge. It is a very compact and dense substance; the dark brownish tint is strongly marked in the middle of the enamel when viewed by transmitted light.

The cells with which the fine tubes of the basal cement communicate, are oblong, about $\frac{1}{2000}$th of an inch across their long axis, which is transverse to that of the tooth; the inter-communicating tubes, which radiate from the cells, giving them a stellate figure. I have entered into these particulars of the microscopic texture of the teeth of the Crocodile because it will be seen in the sequel that important modifications of the dental tissues characterise some of the extinct *Reptilia*.

In the black Alligator of Guiana the first fourteen teeth of the lower jaw are implanted in distinct sockets, the remaining posterior teeth are lodged close together in a continuous groove, in which the divisions for sockets are faintly indicated by vertical ridges, as in the jaws of the Ichthyosaurs. A thin compact floor of bone separates this groove, and the sockets anterior to it, from the large cavity of the ramus of the jaw; it is pierced by blood-vessels for the supply of the pulps of the growing teeth and the vascular dentiparous membrane which lines the alveolar cavities.

The tooth-germ is developed from the membrane covering the angle between the floor and the inner wall of the socket. It becomes in this situation completely enveloped by its capsule, and an enamel-organ is formed at the inner surface of the capsule before the young tooth penetrates the interior of the pulp-cavity of its predecessor.

The matrix of the young growing tooth affects, by its pressure, the inner wall of the socket, and forms for itself a shallow recess; at the same time it attacks the side of the base of the contained tooth; then, gaining a more extensive attachment by its basis and increased size, it penetrates the large pulp-cavity of the previously formed tooth, either by a circular or semicircular perforation. The size of the calcified part of the tooth matrix which has produced the corresponding absorption of the previously formed tooth on the one side, and of the alveolar process on the other, is represented in the second exposed alveolus of the portion of jaw figured in Pl. 75, fig. 4, of my 'Odontography,' the tooth marked *a* in that figure, having been displaced and turned round to show the effects of the stimulus of the pressure. The size of the perforation in the tooth, and of the depression in the jaw, proves them to have been, in great part, caused by the soft matrix, exciting dissolution and absorbent action, and not by mere mechanical force. The resistance of the wall of the pulp-cavity having been thus overcome, the growing tooth and its matrix recede from the temporary alveolar depression, and sink into the substance of the pulp contained in the cavity of the fully-formed tooth. As the new tooth grows, the pulp of the old one is removed; the old tooth itself is next attacked, and the crown being undermined by the absorption of the inner surface of its base, may be broken off by a slight external force, when the point of the new tooth is exposed.

The new tooth disembarrasses itself of the cylindrical base of its predecessor, with which it is sheathed, by maintaining the excitement of the absorbent process so long as the cement of the old fang retains any vital connexion with the periosteum of the socket; but the frail remains of the old cylinder, thus reduced, are sometimes lifted off the socket upon the crown of the new tooth, when they are speedily removed by the action of the jaws. This is, however, the only part of the process which is immediately produced by mechanical force: an attentive observation of the more important previous stages of growth, teaches that the pressure of the growing tooth operates upon the one to be displaced only through the medium of the vital dissolvent and absorbent action which it has excited.

Most of the stages in the development and succession of the teeth of the Crocodiles are described by Cuvier* with his wonted clearness and accuracy; but the mechanical explanation of the expulsion of the old tooth, which Cuvier adopts from M. Tenon, is opposed by the disproportion of the hard part of the new tooth to the vacuity in the walls of the old one, and by the fact that the matter impressing—viz. the uncalcified part of the tooth-matrix—is less dense than the part impressed.

No sooner has the young tooth penetrated the interior of the old one, than another germ begins to be developed from the angle between the base of the young tooth and the inner alveolar process, or in the same relative position as that in which its immediate predecessor began to rise, and the processes of succession and displacement are carried on, uninterruptedly, throughout the long life of these cold-blooded carnivorous reptiles.

From the period of exclusion from the egg, the teeth of the crocodile succeed each other in the vertical direction; none are added from behind forwards, like the true molars in Mammalia. It follows, therefore, that the number of the teeth of the crocodile is as great when it first sees the light as when it has acquired its full size; and, owing to the rapidity of the succession, the cavity at the base of the fully-formed tooth is never consolidated.

The fossil jaws of the extinct Crocodilians demonstrate that the same law regulated the succession of the teeth, at the ancient epochs when those highly organized reptiles prevailed in greatest numbers, and under the most varied generic and specific modifications, as at the present period, when they are reduced to a single family, composed of so few and slightly varied species, as to have constituted in the *Systema Naturæ* of Linnæus, a small fraction of the genus *Lacerta*.

Having completed the analysis of the constituent parts of the framework of the *Crocodilia*, which are petrifiable or conservable in a fossil state, and from the study and comparison of which we have to gain our insight into the nature and affinities of the extinct Reptiles, there remains only to be made a few observations on the characteristic mode in which the bones are associated together in certain parts of the skeleton in the present order, and especially in the skull.

With regard to the trunk, the *Crocodilia* are distinguished from the *Lacertilia* and from all other existing orders of Reptiles, by the articulation of the vertebral ribs (pleurapophyses) in the cervical and anterior part of the dorsal segments by a head and tubercle to a parapophysis and diapophysis. As this double joint is associated with a double ventricle of the heart, and as the single articulation of every rib in other Reptiles is associated with a single ventricle of the heart, we may infer a like difference in the structure of the central organ of circulation in the extinct reptiles, manifesting the above-defined modifications in the proximal joints of the ribs.

* Op. cit., pp. 90-3.

The sacrum consists of two vertebræ only, in *Crocodilia* as in *Lacertilia:* they are modified in the present order, as before described, p. 89.

The skull consists, as we have also seen, of four segments. The hinder or occipital surface of the skull presents, in the *Crocodilia* as in the *Lacertilia*, a single convex occipital condyle, formed principally by the basioccipital, and not showing the trefoil character which it bears in the *Chelonia* (Pl. 11, fig. 4), in which the exoccipitals contribute equal shares to its formation. In the *Batrachia*, the exoccipitals exclusively form the joint with the atlas, and there are accordingly two condyles. The occipital region of the crocodilian skull is remarkable for its solidity and complete ossification, and for the great extent of the surface which descends below the condyle. (Pl. 1 *A*, fig. 2.) In the *Lacertilia*, a wide vacuity is left between the mastoid, exoccipital, and paroccipital; but in the *Crocodilia* this is reduced to the small depressions or foramina near 3, fig. 2, Pl. 1 *A*. The tympanic pedicles (28) extend outwards and downwards, firmly wedged between the paroccipital, mastoid, and squamosal; in the Lacertians these pedicles are suspended vertically from the point of union of the mastoid and paroccipital.

The chief foramen in the occipital region is that called 'foramen magnum' (between 2 and 2, in fig. 2), through which the nervous axis is continued from the skull. On each side of the foramen magnum is a small hole, called 'precondyloid foramen,' for the exit of the hypoglossal nerve. External to this is a larger foramen, marked *n* in fig. 2, for the transmission of the nervus vagus and a vein. Below this is the 'carotid foramen' *c*. All these are perforated in the exoccipital. Below the condyle there is usually a foramen, and sometimes two, for the transmission of blood-vessels. Lower down, at the suture between the basioccipital and basisphenoid, is a larger and more constant median foramen, indicated by the dotted line from *e t;* it is the bony outlet of a median system of eustachian tubes, peculiar to the *Crocodilia*. On each side of the median eustachian foramen, and in the same suture, is a smaller foramen, which is the bony orifice of the ordinary lateral eustachian tube. The membranous continuations of the lateral eustachian tubes unite with the shorter continuation from the median tube, and all three terminate by a common valvular aperture, upon the middle line of the faucial palate, behind the posterior or palatal nostril. The large, bony aperture of this nostril is formed by the pterygoids (24 in fig. 2). The carotid canal, *c*, opens by a short bony tube into the tympanic cavity, and is described as the 'eustachian canal' in the 'Leçons d'Anatomie comparée' of Cuvier. The artery crosses the tympanic cavity, and enters a bony canal at its fore part, which conducts to the 'sella turcica' in the interior of the cranium.

The median eustachian foramen is described by Cuvier as the 'arterial foramen,'* the canal from which divides and terminates in the 'sella turcica.'† By MM. Bronn,

* Ossemens Fossiles, tom. v, pt. ii, p. 133.

† Ib. p. 78.

Kaup, and De Blainville, the median Eustachian foramen is contended to be the bony aperture of the posterior nostrils.*

The results of the dissections and injections of recent Crocodiles and Alligators, by which I have been able to rectify the discrepant opinions regarding the carotid, eustachian, and naso-palatal foramina, and which have led to the discovery of a third median eustachian canal, or rather system of canals, between the tympanic cavities and fauces, peculiar to the Crocodilian Reptiles, are given in detail in the 'Philosophical Transactions' for 1850. The complexity of the superadded system has doubtless chiefly contributed to mislead the justly-esteemed authorities who have believed that they saw in it characters of the carotid canals or of the posterior nasal passages. The eustachian apparatus in the *Crocodilia* may be briefly described as follows: From the floor of each tympanic cavity two air-passages are continued; the canal from the fore part of the cavity extends downwards, backwards, and inwards, in the basisphenoid, which unites with its fellow from the opposite tympanum, to form a short median canal, which descends backwards to the suture between the basisphenoid and the basioccipital, where it joins the median canal formed by the union of the two air-passages from the back part of the floor of the tympanum, which traverse the basioccipital. The common canal formed by the junction of the two median canals descends along the suture to the median foramen *e t*, fig. 2, Pl. 1 *A*. The air-passage from the back part of the tympanum, which traverses the basioccipital, swells out into a rhomboidal sinus in its convergent course towards its fellow, and from this sinus is continued the normal lateral eustachian canal, which, on each side, terminates below in the small aperture, external to the median eustachian foramen.

That part of the outer surface of the skull which is covered by the common integument is more or less sculptured with wrinkles and pits in the *Crocodilia*: the modifications of this pattern are shown in Pl. *A* 2, fig. 1, in the nilotic Crocodile, and in Pl. 1 *A*, in the eocene Crocodile from Hordwell. The flat platform of the upper surface of the cranium is perforated by two large apertures, surrounded by the bones numbered 7, 8, 11, 12; these apertures are the upper outlets of the temporal fossæ, divided from the lower and lateral outlets by the conjoined prolongations of the mastoid 8 and postfrontal 12: if ossification were continued thence to the parietal 7, the temporal fossæ would be roofed over by bone, as in the *Chelones*. In old Crocodiles and Alligators there is an approximation to this structure, and the upper temporal apertures are much diminished in size. In the Gavials (Pl. 1, fig. 1 *a*) they remain more widely open, and, in the fossil Gavials of the secondary strata, they are still wider, as seen in fig. 2 *a*; by which the structure of the cranium approaches more nearly to that of the Lacertian reptiles, where the temporal fossa is either not divided into an upper and lateral outlet, or is bridged over by a very slender longitudinal bar from the postfrontal to the mastoid. The lateral outlets of the temporal fossæ (Pl. 1 *A*,

* Abhandlungen über die Gavialärtigen Reptilien der Lias-formation, folio, 1841, pp. 12, 16, 41.

fig. 1) are divided from the orbits by a bar of bone developed from the postfrontal (12) and malar (26), and against the inner side of the base of which the ectopterygoid abuts; the posterior boundary of the fossa is made by the tympanic (28) and squamosal (27). The orbits, having the postfronto-malar bar (12, 26) behind, are surrounded in the rest of their circumference by the frontal (11), the prefrontal (14), the lachrymal (73), and the malar (26). The supraorbital or palpebral ossicle is rarely preserved in fossil specimens.

The facial or rostral part of the skull anterior to the orbit, is of great extent, broad and flat in the Alligators and some Crocodiles, narrower, rounder, and longer in other Crocodiles, always most narrow, cylindrical, and elongated in the Gavials. The anterior or external nostril is single, and is perforated in the middle of the anterior terminal expansion of the upper jaw. This expansion is least marked in the broad-headed species (compare Pl. 1 *A*, fig. 1, with Pl. 2 *A*, fig. 1); in existing Crocodiles and Alligators the points of the nasal bones penetrate its hind border, as at 15, fig. 1, Pl. *A* 2. In the Gavials (Pl. 1, fig. 1 *a*) the nasals (*n*) terminate a long way from the nostril. The *Crocodilia* resemble the *Chelonia* in the single median nostril.* In the *Lacertilia* there is a pair of nostrils, one on each side the median plane, which is occupied by a bridge of bone extending from the usually single premaxillary to the nasals. The plane of the single nostril is almost horizontal in all existing and tertiary *Crocodilia*.

On the inferior or palatal surface of the skull (Pl. 1 *B*, fig. 2), the most anterior aperture is the circular prepalatal foramen surrounded by the premaxillaries 22; then follows an extensive smooth, horizontal, bony plate, formed by the premaxillaries (22), the maxillaries (21), and the palatines (20). The postpalatal apertures are always large in the *Crocodilia*, and are bounded by the palatines (20), maxillaries (21), pterygoids (24), and ectopterygoids (25). The posterior aperture of the nostril is formed wholly by the pterygoids; it is shown in Pl. 1 *a*, fig. 3, between the bones marked 24. Behind it is the median and lateral eustachian foramen already described, as belonging rather to the posterior region of the head.

CROCODILUS TOLIAPICUS, *Owen*. Pl. 2, 2, *B*, fig. 1.

Syn. CROCODILE DE SHEPPY (?), *Cuvier*. Ossemens Fossiles, 4to, tom. v, pt. ii, p. 165.
CROCODILUS SPENCERI, *Buckland*. Bridgewater Treatise, vol. i, p. 251. "Crocodile with a short and broad snout." Vol. ii, p. 36, pl. 25′, fig. 1.
— — *Owen*. Reports of the British Association, 1841, p. 65.

In proceeding to the comparison, and preparing for the description of the British fossil *Crocodilia*, I endeavoured, in the first place, to obtain the bones of the species

* In a skeleton of the *Alligator lucius* in the Museum of the Royal College of Surgeons, a slender bar of bone is continued from the nasals to the premaxillary, across the median nasal aperture, as it is in the skull of the same species figured in the 'Ossemens Fossiles,' tom. v, pt. ii, pl. i, fig. 8.

which now exists in a locality nearest to Great Britain, and also of an individual of that same species which had lived at a remote period; and I have been favoured by the kindness of my esteemed friend Philip Duncan, Esq., Fellow of New College, Oxford, and Conservator of the Ashmolean Museum, with the opportunity of examining the bones of a mummified Crocodile from a sarcophagus at Thebes, in that collection at Oxford. Two views of the skull of this old Egyptian Crocodile are given in Pl. *A* 2. The total length of the skull from the bone marked 28 to the end of 22, is twice the breadth of the back part of the skull. The upper apertures of the temporal fossa are subcircular; the point of the squamosal (27) projects into the lateral aperture. The breadth of the back part of the sculptured cranial platform (8, 8), is less by one fourth than the breadth of the skull anterior to the orbits. The breadth of the interorbital space is nearly equal to the transverse diameter of the orbit. The points of the nasals (15) project into the external nostril. The postpalatal apertures reach as far forwards as the seventh tooth, counting from the hindmost; there are nineteen alveoli on each side of the upper jaw, the five anterior teeth being lodged in the premaxillary, which is perforated by the first tooth of the lower jaw.

Geoffroy St. Hilaire has applied the old Egyptian name Σοῦχος to the mummified Crocodiles of that country; but there is no good specific character which distinguishes them from the modern Crocodiles of the Nile, to which Cuvier has given the name of *Crocodilus vulgaris.*

Cuvier appears to have first called the attention of palæontologists to the remains of *Crocodilia* in the Eocene clay forming the Isle of Sheppy, in the last volume of the second edition of his great work on the 'Ossemens Fossiles,' p. 165, 1824. He there specifies a third cervical vertebra, which was obtained by M. G. A. Deluc, at Sheppy, and of which Cuvier made a drawing at Geneva; he says it much resembles the corresponding vertebra in one of our living Crocodiles, and might have come from an individual about five feet in length. "M. Deluc," he adds, "found very near it a much smaller vertebra, which I recognised as belonging to a monitor or some allied genus."*

Our knowledge of the Eocene Crocodiles of Sheppy received a remarkable accession at the publication of the highly interesting and instructive 'Bridgewater Treatise' of Dr. Buckland, in which he states that "true Crocodiles, with a short and broad snout, like that of the Caiman and the Alligator, appear, for the first time, in strata of the tertiary periods, in which the remains of mammalia abound. . . . One of these," he adds, "found by Mr. Spencer in the London Clay of the Isle of Sheppy, is engraved Pl. 25′, fig. 1," and the name '*Crocodilus Spenceri*' is appended to that figure.

* Could this have been a vertebra of the large serpent, which I have subsequently described under the name of *Palæophis?* I have not as yet met with a single lacertian vertebra from Sheppy. If the collection of M. Deluc be still preserved at Geneva, the vertebra in question might be compared with the figures of the *Palæophus toliapicus*, 'Ophidia,' Pl. 1.

In preparing my 'Report on British Fossil Reptiles' for the British Association in 1841, I examined the original specimen figured by Dr. Buckland, in which unfortunately the end of the snout with the intermaxillaries and an indeterminate proportion of the maxillaries having been broken off and lost, no exact idea could be formed of the proportions of the facial or rostral part of the skull.

In a larger specimen of the fossil skull of a Crocodile from Sheppy, in the British Museum, the whole of the upper, as well as the lower jaw, were preserved, and as the proportions of the snout agreed with those of some true Crocodiles, and differed in an equal degree with those species from the Gavial; and as, like the Crocodiles and Caimans, it presented the more important distinction of a different composition of that part of the skull, I retained for the specimen in that 'Report' the name of *Crocodilus Spenceri*, proposed by the author of the Bridgewater Treatise for the Sheppy Crocodile, so differing from the Gavial.

The able keeper of the Mineralogical Department of the British Museum, Charles König, K.H., F.R.S., to whom I am indebted for every facility in describing and figuring this specimen, has suggested that the name by which Baron Cuvier first indicated the existence of a true Crocodile in the Eocene clay of Sheppy, should have the priority, and I adopt, therefore, the name *Crocodilus toliapicus*, which he has attached to the specimen in question, and with the more readiness since I have now reason to doubt whether the mutilated cranium, figured in the 'Bridgewater Treatise,' belongs to the same species.

The more entire fossil skull in question presents the following dimensions:

	Feet.	Inches.	Lines.
Total length from the hindmost part of the lower jaw .	2	2	0
Breadth between the articular ends of the tympanics .	0	10	0
Do. across the orbits	0	7	6
Do. of the intertemporal space	0	0	9
Do. of the interorbital space	0	1	4
From the articular end of the tympanic to the orbit .	0	8	6
From the occipital condyle to the orbit	0	7	0
From the orbit to the external nostril	0	14	0
Breadth of the cranium five inches in advance of the orbits	0	3	8
Do. across the external nostril	0	2	8
Depth of the lower jaw at the vacuity between the angular and surangular	0	3	6
Length of that vacuity	0	3	0
Breadth of the base of one of the larger maxillary teeth .	0	0	8

This remarkably fine fossil skull, which is figured one third of its natural size in Pl. 2, and Pl. 2 *B*, fig 1, presents proportions which come nearest to those of the *Crocodilus acutus*, being longer in proportion to its basal breadth than in the *Crocodilus Suchus*, in which the diameter between the articular ends of the tympanis (28) is just half the length of the entire skull. The interorbital space in the *Crocodilus toliapicus* is relatively

narrower and flatter than in the *Croc. acutus* or *Croc. Suchus*, and the facial part of the skull becomes narrower before the expansion of the upper jaw, at the figure 15, than it does in either of those species. The narrow elongated nasals on which the figure 15 is placed, extend forwards to the external nostril (22), as in the true Crocodiles, and the alveolar border is festooned as is shown in the side view in Pl. 2. The teeth are $\frac{22-22}{20-20}=84$ in number: they are more uniform in size, and more regularly spaced than in the recent species above cited, and resemble in this respect the teeth of the *Crocodilus Schlegelii* of S. Müller, which is from Borneo. The extent of the symphysis of the lower jaw is greater in the *Crocodilus toliapicus* than in the *Croc. acutus,* and the Sheppy species in this respect more nearly resembles the living species from Borneo above cited.

CROCODILUS CHAMPSOIDES, *Owen.* Plates 2 *A*, 2 *B*, fig. 2.

Syn. CROCODILE DE SHEPPY (?), *Cuvier.* Loc. cit.
CROCOCILUS SPENCERI, *Buckland.* Bridgewater Treatise, vol. ii, pl. xxv, fig. 1.

The fossil skull already described establishes the fact of the existence of a true Crocodile in the London Clay at Sheppy, but not of a species with a short and broad snout; the present specimen equally demonstrates the presence at the earliest period of the Tertiary geological epoch of *Crocodilia* with those modifications of the cranial and dental structure on which the characters of the restricted genus *Crocodilus* of modern Zoology are founded, but they are associated with a general form of the head which approaches more nearly to the Gavials than does that of the *Crocodilus toliapicus,* and which are most nearly paralleled amongst the known existing true Crocodiles by the *Crocodilus Schlegelii.* This Bornean species was, in fact, originally described as a new species of *Gavial,* but the nasal bones, as in the fossil from Sheppy figured in Pl. 2 *A*, 15, extend to the hind border of the external nostril.

The fine subject of Plate 2 *A*, forms part of the collection of J. S. Bowerbank, Esq. F.R.S., which is well known for its rich and varied illustrations of the fossils of the Isle of Sheppy.

The following are some of its admeasurements:

	Feet.	Inches.	Lines.
Total length from the occipital condyle to the end of the premaxillaries	1	4	0
Breadth across the hinder angles of the supracranial platform	0	4	0
Do. across the orbits	0	5	0
Do. of the intertemporal space	0	0	4
Do. of the interorbital space	0	1	0
Do. across the external nostril	0	2	0
From the occipital condyle to the orbit	0	3	4
From the orbit to the external nostril	3	10	0

The skull yielding the above dimensions is much smaller than that of the *Crocodilus toliapicus*, Pl. 2 *B*; but it cannot have belonged to a younger individual of the same species, because, in existing Crocodiles, the part of the skull anterior to the orbits is proportionally shorter in the young than in the old individuals, as may be seen by comparing the figures which Cuvier has given of the skulls of three individuals of different ages of the *Crocodilus biporcatus*, in figures 4, 18, and 19, of plate 1 of the last volume of the 'Ossemens Fossiles;' whereas the part of the skull anterior to the orbits is relatively longer and more slender in the smaller fossil skull now described than in the larger one on which the species *Croc. toliapicus* is founded. We have, therefore, satisfactory proof that two species of true Crocodile existed during the deposition of the Eocene Clay at the actual mouth of the Thames, and have left their remains in that locality.

Their specific distinction is further illustrated by the different forms and proportions of particular parts of the skull. The alveolar border is more nearly straight; the transverse expansion of the maxillaries (21) is less, whilst that of the premaxillaries (22) is greater: the interorbital space is broader and more concave. The teeth are more uniform in size, are more regularly spaced, and are wider apart: they are, likewise, upon the whole, larger in proportion to the size of the jaw. Figure 5, Pl. 2 *A*, shows the crown of a new tooth just emerging from the second socket of the maxillary bone of the natural size; figure 6 is the fourth tooth of the premaxillary, fully formed; fig. 7 is the displaced tooth which is cemented by the matrix to the palatal surface of the premaxillary in fig. 2. The enamelled crown shows the fine raised longitudinal ridges better developed than one usually sees them in modern Crocodiles. There are twenty-one alveoli on each side of the upper jaw.

In all the particulars in which the skull under description differs from that of the *Crocodilus toliapicus*, it departs further from the nilotic crocodile, and resembles more the Gavial-like Crocodile of Borneo; and as one of the old Egyptian names of the Crocodile, *Champsa*, has been applied generically to the Gavials by some recent Erpetologists, I have adopted the term '*Champsoides*' to signify the resemblance of the present extinct species of Eocene Crocodile to the Gavials.

The basioccipital condyle, together with the condyloid processes of the exoccipital, project backwards in the *Croc. champsoides* farther than in any modern Crocodile; and the supraoccipital 3, fig. 4, Pl. 2 *A*, descends nearer to the foramen magnum.

The upper jaw is more depressed, and the suborbital part of the maxillary bone is much less inclined to the vertical in the present skull than in the original of Dr. Buckland's figure of the *Crocodilus Spenceri*, which in other respects more nearly resembles the *Croc. champsoides* than the *Croc. toliapicus*; the difference above specified seems to be greater than can be accounted for by any accidental pressure to which the fossil skull figured in Pl. 2 *A* can have been subjected. The mutilated skull to which the term *Croc. Spenceri* was originally applied, is defective, as I have said, in the

facial or maxillary portion which is requisite for its unequivocal determination to either of the two species which the more perfect specimens since acquired have proved to have existed at the Eocene tertiary period. The form of the mutilated portion of skull, and the figure of it given in Pl. 25′ of the 'Bridgewater Treatise,' might well appear to indicate a short and broad snouted species of true Crocodile; but if it be not distinct from the two better represented species above described, I should be more inclined to refer it to that which has the longest and narrowest snout, from the conformity of the characters of the part of the skull which is preserved. A view of the palatal surface of the specimen in question is given in Pl. 2 *B*, fig. 2.

Crocodilian vertebræ referable to the two foregoing species of Sheppy Crocodiles.

Not more than two species of Crocodile are indicated by the detached vertebræ from Sheppy; but the different proportions of the homologous cervical vertebræ, figs. 3 and 7, Pl. 3 *A*, and of the characteristic biconvex caudal vertebra, fig. 7, Pl. 3, and fig. 10, Plate 3 *A*, would have determined the fact of there being two distinct species, had their cranial characters, which are so satisfactorily demonstrated in Plates 2 and 2 *A*, remained unknown. I refer, provisionally, the shorter and thicker vertebræ to the *Crocodilus toliapicus* with the shorter and thicker snout, and the longer and thinner vertebræ to the *Croc. champsoïdes* with the snout of similar proportions.

Vertebræ of the CROCODILUS TOLIAPICUS, Plate 3 and Plate 3 *A*, figs. 1, 2, 3, 5, 6.

The vertebra, figs. 1, 2, Pl. 3 *A*, is the fourth cervical; it differs from that of the *Crocodilus acutus*, *Croc. Suchus*, and *Croc. biporcatus*, in the greater breadth and squareness of the base of the hypapophysis (fig. 2 *h*), which extends almost to the bases of the parapophyses *p*; the vertical diameter of the parapophyses is greater in comparison with their antero-posterior extent in the fossil than in the above-cited recent Crocodiles; the neurapophyses are thicker, and terminate in a more rounded border both before and behind; their bases extend inwards, and meet above the centrum, whilst a narrow groove divides them in the recent Crocodiles above cited; the length of the centrum is greater in proportion to the height and breadth in the fossil vertebra. In other respects the correspondence is very close, and the modern crocodilian characters are closely repeated. Traces of the suture between the centrum and neurapophysis remain, as shown at *n*, *n*, fig. 1. The diapophysis *d*, and the upper portion of the neural arch, with the zygapophyses and neural spine, have been broken away; the borders of the articular ends of the centrum have been worn away.

The vertebra (fig. 3, Pl. 3 *A*) is the sixth cervical: in this specimen the base of the hypapophysis is contracted laterally and extended antero-posteriorly; the side of the centrum above the parapophysis (*p*) has become less concave; the vertebra has increased

more in thickness than in length; in these changes it corresponds with the modern Crocodiles; it has been mutilated and worn in almost the same manner and degree as the fourth cervical.

The vertebra (figs. 1, 2, Pl. 3) is a seventh cervical of a smaller individual of the *Crocodilus toliapicus*. The hypapophysis has become more compressed and more extended antero-posteriorly; the parapophysis has become shortened antero-posteriorly, and increased in vertical diameter. The anterior concave surface of the centrum (fig. 1) is more circular, less extended transversely, than in the corresponding vertebra of the recent Crocodiles compared with the fossil.

Figures 3, 4, Pl. 3, are two views of the eighth cervical of an individual of about the same size as that to which the fourth and sixth cervicals in Pl. 3 *A* belong. Fig. 4, exemplifies the same difference which fig. 1 presents in regard to the more circular contour of the anterior concave surface of the centrum as compared with recent Crocodiles; the bases of the neurapophyses are thicker and more rounded anteriorly; the neural canal is rather more contracted; the base of the hypapophysis more extended in the axis of the vertebra (see fig. 3) than in the recent Crocodiles compared. The parapophyses have now risen, as in those Crocodiles, to the suture of the neurapophysis, and the diapophysis springs out at some distance above that suture.

Fig. 6, Pl. 3, shows the under surface of a dorsal vertebra, in which the hypapophysis ceases to be developed (probably the fourth or fifth).

Fig. 5, Pl. 30, gives the same view of one of the lumbar vertebræ, showing the elongation of the centrum, and the broad bases of the depressed diapophyses; there is an indication of two longitudinal risings towards the back part of the under surface of the centrum.

Figs. 5 and 6, Pl. 3 *A*, give two views of the anterior sacral vertebra of the *Crocodilus toliapicus;* it is concave and much expanded transversely at its fore part (fig. 5), flattened and contracted behind. Traces of the suture remain to show the proportion of the anterior articular surface which is formed by the base of the pleurapophysis *p*; and fig. 6 shows the extension of that base from the side of the centrum upon the diapophysis or overhanging base of the neurapophysis; the under surface of the centrum of this vertebra has a slight median longitudinal rising.

Fig. 7, Pl. 3, gives a side view of the characteristic, biconvex, anterior caudal vertebra of the *Crocodilus toliapicus*.

Figs. 8, 9, Pl. 3, give two views of a middle caudal vertebra: in fig. 9 are shown the characteristic hypapophysial ridges extending from the articular surfaces for the hæmapophyses at the hind part of that aspect of the centrum: in fig. 8 the processes of the neural arch are restored in outline; a thick and low ridge extends from the middle of the side of the centrum to the base of the transverse process which it strengthens, like an underpropping buttress.

Vertebræ of the CROCODILUS CHAMPSOÏDES.

Figures 7 and 8, Pl. 3 *A*, give two views of the third cervical vertebra of the above-named gavial-like Crocodile, which vertebra, besides its longer and more slender proportions, differs in the smaller size of its hypapophysis from the corresponding vertebra in any existing species of Crocodile or Gavial: the process in question being in the form of a low crescentic ridge, as shown at figure 8, between the bases of the parapophyses (*p*).

Both parapophyses terminate by a convex surface, which appears to have been a natural one. Between the parapophysis (*p*) and diapophysis (*d*), fig. 7, the side of the centrum is more deeply excavated than in the *Crocodilus toliapicus*. The centrum contributes a small part to the base of the diapophysis, as in the third cervical vertebra of modern Crocodiles. The neurapophysis are thinner than in the *Croc. toliapicus*, and their bases do not join one another above the centrum. The longitudinal ridge extending from the anterior to the posterior zygapophysis is sharply defined.

Figure 4, Pl. 3 *A*, is the first dorsal vertebra of the *Crocodilus champsoïdes*, in which, as in existing Crocodiles, the parapophysis (*p*) has passed almost wholly from the centrum upon the neurapophysis, the diapophysis (*d*) having been subject to a corresponding ascent. The base of the compressed hypapophysis extends over the anterior third of the middle line of the under surface of the centrum. There is a remarkable transverse constriction at the base of the posterior ball of the centrum, as if a string had been tied round that part when it was soft, and there is no appearance of this groove having been produced by any erosion of the fossil, or being otherwise than natural.

The same character is repeated, though with less force, in the posterior dorsal vertebra, fig. 9, Pl. 3 *A*, and, together with the general proportions of the specimen, supports the reference of that vertebra to the *Crocodilus champsoïdes*. There is a slight longitudinal depression at the middle of the side of the centrum near the suture with the neurapophysis (*n*, *n*).

Figure 10 is a side view of the first caudal vertebra of the *Crocodilus champsoïdes*: besides being longer and more slender than that vertebra is in the *Croc. toliapicus*, the inferior surface of the centrum is less concave from before backwards.

The evidences of Crocodilian reptiles from the deposits at Sheppy less characteristic of particular species than those above described, are abundant. Mr. Bowerbank possesses numerous rolled and fractured vertebræ, condyloid extremities, and other portions of long bones; with fragments of jaws and teeth.

Mr. J. Whickham Flower, F.G.S., has transmitted to me some fragments of the skull of a Crocodile from Sheppy, including the articular end of the tympanic bone, equalling in size that of a *Crocodilus biporcatus* the skull of which measures two feet eight inches in length.

Mr. Leifchild, C.E., possesses a considerable portion of the lower jaw of a Crocodile

of at least equal dimensions, also from Sheppy, showing the angle of union of the rami of the lower jaw which corresponds with that in the *Crocodilus toliapicus*, Pl. 2.

In the museum of my esteemed and lamented friend, the late Frederic Dixon, Esq., F.G.S., at Worthing, is preserved a portion of the fossilized skeleton of a Crocodile, from the Eocene clay at Bognor, in Sussex ; it consists of a chain of eight vertebræ, including the lumbar, sacral, and the biconvex first caudal, which are represented of their natural size in tab. xv, of Mr. Dixon's beautiful and valuable work on the 'Geology of Sussex.' A dorso-lateral bony scute adheres to the same mass of clay close to the vertebræ, and doubtless belonged to the same individual. The proportions of the vertebræ agree with those of the *Crocodilus toliapicus.* This fine specimen was discovered, and presented to Mr. Dixon, by the Rev. John Austin, M.A., Rector of Pulbrough, Sussex. Mr. Dixon had also obtained from the same locality a posterior cervical vertebra of a Crocodile, similar in its general characters to those above mentioned, but belonging to a larger individual. The length of the body of this vertebra is two inches and a half.

I have examined some remains of *Crocodilia* from the London Clay at Hackney; but as these also are not sufficiently perfect or characteristic for decided specific determination, no adequate advantage would be obtained by a particular description, or by figures of them.

The chief conclusion arrived at from the study of the Crocodilian fossils from the Island of Sheppy has been the proof, by the specimens selected for depiction in the present work, that at least two species of true *Crocodile* have left their remains in that locality; that neither of these had a short and broad snout like the Caimans, but that one of them—the *Croc. champsoïdes*—much more nearly resembled the Gavial of the Ganges in the proportion of that part of the skull; although, in its composition, especially as regards the length and connexions of the nasal bones, it is a true Crocodile.

Amongst the existing species of Crocodile the *Croc. acutus* of the West Indies offers the nearest approach to the *Croc. toliapicus*, and the *Croc. Schlegelii* of Borneo, most resembles the *Croc. champsoïdes.* But there are well-marked characters in both the skull and the vertebræ which specifically distinguish the two fossil Crocodiles of Sheppy from their above-cited nearest existing congeners.

CROCODILUS HASTINGSIÆ, *Owen.* Plates 1 *A*, 1 *B*, 1 *C*, fig. 1 and Pl. 1 *E*, figs. 2 and 5.

Reports of the British Association, 1847, p. 65.

That Crocodiles with proportions of the jaws assigned to the Eocene species noticed in Dr. Buckland's 'Bridgewater Treatise' and especially adapted for grappling with strong mammiferous animals, actually existed at that ancient tertiary epoch, and have left their remains in this island, is shown by the singularly perfect fossil skull figured in the above-cited plates. This specimen was discovered by the Marchioness of Hastings, in the Eocene fresh-water deposits of the Hordle Cliffs in Hampshire, which her

Ladyship has described in the volume of 'Reports of the British Association' above cited, (p. 63).

When the specimen was originally exposed, it was in the same extremely fragile and crumbling state as the beautiful carapaces of *Trionyx* obtained by Lady Hastings from the same locality, and described and figured in the chapter *Chelonia ;* but thanks to the skill and care with which the noble and accomplished discoverer readjusted and cemented the numerous detached fragments of those specimens, the present unique fossil has been in like manner restored as nearly to its original state as is represented in the plates ; and all the requisite characters for determining the nature and affinities of the species, can now be studied with the same facility as in the skulls of existing Crocodiles.

If the reader will compare the plates above cited with the section of Cuvier's 'Ossemens Fossiles,' in which the distinctions between the Alligators and Crocodiles are specified,* he will see, (in fig. 1, Pl. 1 *B*) for example, that the fourth tooth or canine of the lower jaw is not received into a circumscribed cavity of the upper jaw, but is applied to a groove upon the side of the upper jaw, and is exposed. Fig. 1, Pl. 1 *A*, shows that the prefrontal (14) and lachrymal (73) bones, instead of descending much less upon the facial part of the skull, extend much more, and advance nearer to the end of the muzzle than in any Alligator, or even than in any actual species of broad-nosed Crocodile.

The vacuities left between the postfrontal (12), the parietal (7), and the mastoid (8) (Pl. 1 *A*, fig. 1, and Pl. 2 *B*, fig. 3), are as wide as in the skull of a *Crocodilus biporcatus* of equal size, and are larger than in the *Alligator lucius* or *All. sclerops*. Fig. 2, Pl. 1 *B*, shows that no part of the vomer is visible between the premaxillaries (22) and maxillaries (21), or elsewhere on the palate. But the palatine expansion of the vomer is not a constant character ; it is wanting, for example, in the *Alligator lucius* of North America. The palatines (20) are not more advanced in the fossil in question than they are in the true Crocodiles, and their anterior portion does not expand to its anterior truncated termination. The posterior nostril, the entire contour of which is shown in the portion of the skull of the same species figured in Pl. 1 *A*, fig. 3, is longer than it is broad.

There is but one character in which the fossil skull in question differs from the true Crocodile, and agrees with most species of Alligator; it is in the reception of the two anterior teeth of the lower jaw into cavities of the premaxillaries, shown in

* "Les têtes des caïmans, outre le nombre des dents, et surtout la manière dont la quatrième d'en bas est reçue, outre les différences qui dépendent de la circonscription totale, se distinguent de celles des Crocodiles proprement dits, 1°, parce que le frontal antérieur et le lacrymal descendent beaucoup moins sur le museau ; 2°, en ce que les trous percés à la face supérieure du crâne, entre le frontal postérieur, le pariétal et le mastoïdien, y sont beaucoup plus petits, souvent même y disparaissent tout-à-fait, comme dans le caïman à paupières osseuses ; 3°, en ce que l'on aperçoit une partie du vomer dans le palais, entre les intermaxillaires et les maxillaires ; 4°, en ce que les palatins avancent plus dans ce même palais, et s'y élargissent en avant ; 5°, en ce que les narines postérieures y sont plus larges que longues, etc." (tom. v, pt. ii, p. 105.)

fig. 2, Pl. 1 *B*, which are not perforated; so that there are no foramina anterior to the bony nostril, as in Pl. *A* 2, in the bone marked 22. These foramina are not, however, absent in all Alligators; the skull of the *Alligator sclerops*, figured by Cuvier (tom. cit., pl. i, fig. 7), shows them, as do all the species of true Crocodile the skulls of which are figured in the same plate. There is one character by which the *Crocodilus Hastingsiæ* differs from all known species of both Crocodile and Alligator: it is that afforded by the broad and short nasal bones (15, fig. 1, Pl. 1 *A*), which do not reach the external nostril; this being formed, as in the Gavials, exclusively by the premaxillaries 22.

In the general proportions, however, of the skull in question, especially the great breadth, shortness, and flatness of the obtusely-rounded snout, it resembles that of the Alligators more than that of any known species of true Crocodile, the length from the tympanic condyle to the end of the snout being to the breadth taken at the condyles as 16 to 9.

The following are dimensions of the fossil in question:

	Feet.	Inches.	Lines.
Length of skull from the angle of the lower jaw to the end of the snout . . .	1	6	6
Do. from the tympanic condyle to ditto. .	1	4	6
Do. do. to the orbit	0	5	4
Do. from the orbit to the external nostril .	0	7	0
Breadth of the skull across the tympanic condyles .	0	9	3
Do. the orbits . . .	0	7	0
Do. the external nostril . .	0	4	0
Longest diameter of upper temporal aperture . .	0	1	9
Do. the post-palatal vacuities . .	0	4	9
Depth of the lower jaw at the posterior vacuity . .	0	3	0
Depth of the occipital region	0	4	3

The occipital region of the skull (Pl. 1 *A*, fig. 2), in the proportion of its breadth to the depth of the lateral parts formed by the conjoined paroccipitals (4) and mastoids (8), resembles that of the true Crocodiles rather than that of the Alligators, in which that region is proportionally deeper than in the Crocodiles; the vertical extent of the supraoccipital is less, and that of the conjoined parts of the exoccipitals above the foramen magnum is greater; the vertical extent of the descending part of the basioccipital is also greater in proportion to its breadth than in the Alligators. The proportion of the basisphenoid (5) and of the conjoined parts of the pterygoids (24) which appear in this view (fig. 2), is less than in the Alligators, but is greater than in most Crocodiles, thus presenting an intermediate character; but the entire exclusion of any part of the posterior nostril from this view is a character of the Alligators, and is due to the horizontal plane of that aperture in them, and to its position in advance of the posterior border of the pterygoids, from which it is partitioned off usually by a bony ridge. The posterior nostril has the same position and aspect in the *Crocodilus Hastingsiæ*, and these characters of the posterior nostril are perhaps more distinctive between

Alligator and Crocodile than the shape of the aperture, in which the present fossil differs from both the Alligators and most of the Crocodiles with which I have compared it. The backward extension of the exoccipitals and of the basioccipital condyle, is such as to bring both parts into view in looking directly upon the middle of the upper surface of the skull, as in Pl. 1 *A*, fig. 1. In this character the fossil resembles the Crocodiles more than the Alligators, but the projection is greater than in existing Crocodiles, and equals that in the Sheppy *Crocodilus champsoïdes*.

On the upper surface of the skull a distinctive character has been pointed out by Cuvier in the different proportions of the supra-temporal apertures in the Alligators and Crocodiles. The horizontal platform in which these apertures are perforated, is also square in the Alligators; the mastoidal angles being less produced outwards and backwards, and the postfrontal angles less rounded off; this difference is shown in the skulls figured in Cuvier's pl. i, tom. cit. The *Croc. Hastingsiæ*, both by the obtuseness of the postfrontal angles, and the acuteness and production of the mastoidal angles, resembles the Crocodiles, as well as by the size of the supra-temporal apertures; these are ovate with the small end turned forwards and a little outwards.

Another character may be noticed in the figures of the skulls of the three species of Alligators as compared with those of the three species of Crocodile in Cuvier's pl. i, viz. the larger proportional size of the orbits in the former, in which the orbit much exceeds in size the lateral temporal aperture. In the *Alligator niger*, also, I find the orbits enormous, and it is the encroachment of the narrow anterior part of the orbital cavity upon the facial part of the prefrontal and lachrymal, that renders that part of those bones relatively shorter in the Alligators. In the *Crocodilus Hastingsiæ* the proportions of the lateral temporal apertures (Pl. 1 *A*, fig. 1, 12, 26) and orbital (11, 14, 73) apertures, are like those in the species of Crocodile in which the orbits are smallest. The extent of the facial part of the prefrontal (14) and lachrymal (73) is greater in the *Croc. Hastingsiæ* than in any existing species of true Crocodile. Another characteristic of the present fossil presented by the upper surface of the skull, is the shortness as well as breadth of the nasal bones, and their almost truncate anterior termination at nearly one inch from the external nostril. In all the Alligators' skulls that I have examined or seen figured, the nasal bones are broadest at their posterior third part, and converge to a point anteriorly, where in the *Alligator lucius*, e. g., they extend across the nasal aperture.

The interorbital space is slightly concave in the *Crocodilus Hastingsiæ;* two broad and slightly elevated longitudinal tracts are continued forwards upon the face from the fore part of the orbits; but they are not developed into ridges, as in the *Croc. biporcatus*. The maxillaries swell out a little in advance of the middle of the nasals, and then contract to the crocodilian constriction at the suture with the premaxillaries, where the tips of the lower canines appear in the upper view (fig. 1, Pl. 1 *A*), and their whole crown is exposed in the side view (fig. 1, Pl. 1 *B*). The conjoined parts of the premaxillaries send a short pointed projection into the back part of the external nostril.

On the under or palatal surface of the skull (Pl. 1 *B*, fig. 2) the maxillo-premaxillary suture runs almost transversely across, as in the *Crocodilus rhombifer*, figured by Cuvier in pl. iii, fig. 2, of the volume above cited. There is no appearance of the vomer upon the palate. The palatal bones (20), though somewhat broader anteriorly, and more abruptly truncate than in any existing Crocodile that I have seen, are more like those bones in the true Crocodiles than in the Alligators. The portion between the post-palatal vacuities is longer and narrower; the posterior end of the palatines is narrower, and the part of the bone anterior to the notch receiving the posterior angle of the palatal plate of the maxillary does not expand in advancing forwards, as it does in the Alligators: in the *Alligator niger* this expansion is greater than in the *All. lucius*, and the posterior ends of the palatines are also remarkably expanded, and applied to the anterior borders of the pterygoids almost as far as their articulation with the ectopterygoids, the postpalatal vacuities not at all encroaching on the pterygoids, as they are seen to do at 24, Pl. 1 *B*, fig. 2, and also in the figure of the *Crocodilus rhombifer* above cited, and in other true Crocodiles. The form of the pterygoids (24, Pl. 1 *B*, fig. 2) is peculiar in the *Crocodilus Hastingsiæ:* they are contracted anteriorly, and send forwards a short truncated process to meet the narrow posterior ends of the palatines (20); and the same character being repeated in another skull of the same species, from Hordle, also in the collection of Lady Hastings, in which this part of the bony palate (Pl. 1 *A*, fig. 3) is more perfect than in the subject of Pl. 1 *B*, fig. 2, it may be regarded with some confidence as specific. In the *Crocodilus champsoïdes* of Sheppy it will be seen, by fig. 2, Pl. 2 *B*, that the pterygoids (24, 24) are not produced where they join the palatines (20). In the Alligators, the posterior border of the conjoined pterygoids is deeply notched behind the posterior nostrils, the angles of the notch being slightly extended backwards: in most Crocodiles, the sides of the notch are so developed that it does not sink deeper than the line of the posterior border of the pterygoids; and this modification is exaggerated in the *Crocodilus Hastingsiæ* (Pl. 1 *A*, fig. 3) in which the notch in question is merely the interval between two slender diverging processes from the middle of the back part of the pterygoids, 24. The posterior aperture of the nasal passages is wholly surrounded in the *Crocodilus Hastingsiæ* by the horizontal plate of the pterygoids, and has the same position and aspect as in the Alligators; but its form is heart-shaped, with the apex directed backwards, and the antero-posterior diameter exceeding the transverse one. I have not met with this form of the posterior nostril in any other species of Crocodilian; but it is repeated in two individuals of the *Croc. Hastingsiæ*, and may be regarded as a specific character.

The ectopterygoid, 25, Pl. 1 *A*, fig. 3, Pl. 1 *B*, fig. 2 (*d*, fig. 2, pl. iii, 'Ossemens Fossiles,' t. v, pt. ii) articulates with a larger proportion of the outer surface of the pterygoids (24) in the Crocodiles than in the Alligators: it agrees with the Crocodiles in the extent of this articulation in the *Croc. Hastingsiæ*.

The number of teeth in this species is $\frac{22-22}{20-20} = 84$.

In the upper jaw the fourth, ninth, and tenth are the largest; and the fifteenth and sixteenth exceed in size those immediately before and behind them. The alveolar border of the jaw increases in depth to form the sockets requisite for firmly lodging these larger teeth, and gives rise to the festooned outline of the jaw, which is found in all Crocodiles and Alligators in proportion as the teeth are unequal in size.

The lower jaw presents the same compound structure as that in the *Crocodilia*, with the general form characteristic of that in the Alligators and in most of the true Crocodiles: the symphysis, e. g. is as short as *Crocodilus biporcatus* and the *Alligator niger*, in which it extends as far back as the interval between the fourth and fifth socket. This is the relative position of the back end of the symphysis in a fine and perfect under jaw of the *Crocodilus Hastingsiæ* in the collection of the Marchioness of Hastings. In a portion of the under jaw of apparently the same species of Crocodile, from the same locality, in the collection of Searles Wood, Esq., F. G. S., the symphysis terminates opposite the interval between the third and fourth tooth.

The chief distinction observable between the modern Crocodiles and Alligators in the lower jaw is the greater relative size of the vacuity between the angular (30) and surangular (29) pieces, and the greater relative depth of the ramus at that part, in the Alligators. In these characters the lower jaw of the present species more resembles that of the true Crocodiles; although, as the vacuity in question is somewhat larger, a slight affinity to the Alligator might be inferred from that circumstance. The comparative figures of the hinder third of the mandibular ramus in Plate 1 *E*, figs. 4, 5, 6, will exemplify the difference in question, and the degree of proximity to the crocodilian and alligatorial characters respectively.

With regard to another character deducible from the relation of the backwardly-produced angle of the jaw to the articular surface, the *Crocodilus Hastingsiæ* more decidedly resembles the Alligator: I allude to the depth of the excavation between the articular cavity (29) and the end of the angle (30), and to the lower or higher level of the angle itself: the fossil jaw (fig. 5) resembles the Alligator (fig. 6) in this respect more than the Crocodile (fig. 4). The alveoli are twenty in number in each ramus of the *Crocodilus Hastingsiæ:* the third and fourth are large, of equal size, and close together; behind these the eleventh, twelfth, and thirteenth are the largest, and the alveolar ridge is raised to support them; after the seventeenth the summits of the crowns of the teeth become obtuse, and the crowns mammilloid, and divided by a constriction or neck from the fang; they each, however, have a separate socket, as in the Crocodiles, the septa not being incomplete at the hinder termination of the dental series, as in the *Alligator niger* figured in my 'Odontography.'*

Fig. 3, Pl. 2 *B*, gives a representation, of the natural size, of the cranial platform of a young *Crocodilus Hastingsiæ* in the collection of Searles Wood, Esq.; the hemispheric depressions in the surface of the bone are more regular, distinct, and relatively

* Tom. ii, pl. lxxv, fig. 3.

larger, and the interorbital part of the frontal is narrower, concomitantly with the larger proportional eyeballs and orbits of the young animal. The relatively larger supratemporal apertures form another character of nonage; but there is no ground for deducing a specific distinction from any of the differences observable between this part of the young crocodile's cranium and the corresponding part of that of the more mature specimen (Pl. 1 *A*).

ALLIGATOR HANTONIENSIS, *Wood.* Plate 1 *C*, fig. 2.

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On reviewing the characters of the skull of the *Crocodilus Hastingsiæ* we perceive that they combine to a certain extent those which have been attributed to the genus *Crocodilus* and the genus *Alligator;* in general form it resembles most the latter, but agrees with the former in some of the particulars that have been regarded by Cuvier and other palæontologists as characteristic of the true Crocodiles. I allude more particularly to the exposed position of the inferior canines when the mouth is shut. Respecting which, however, I am disposed to ask, whether this be truly a distinctive character of importance? One sees that it needs but a slight extension of ossification from the outer border of the groove to convert it into a pit; yet the character has never been found to fail as discriminative of the several species of existing Crocodiles and Alligators hitherto determined. It constitutes, however, the only difference between the skulls of the *Crocodilus Hastingsiæ* in the collection of the Marchioness of Hastings and that fine portion of skull now, by the kindness of Mr. Searles Wood, before me, on which he has founded the species named at the head of the present section. So closely, in fact, do those specimens from the same rich locality correspond, that any other comparative view than that given in Pl. 1 *C* appeared superfluous. In both the broad nasal bones terminate at the same distance from the external nostril, which is accordingly formed exclusively by the premaxillaries; in both, the palate-bones present the same narrow, truncate posterior ends, and the same equal breadth of their anterior portions included between the maxillaries; only these terminate rather more obliquely in Mr. Wood's specimen, their anterior ends forming together a very obtuse angle directed forwards. But this is comparatively an unimportant difference, and I regard as equally insignificant the slight interruption of the transverse line of the maxillo-premaxillary suture, at the middle part, which will be seen by comparing fig. 2 with fig. 1, in Pl. 1 *C*. The teeth are the same in number, arrangement, and proportion in the *Alligator Hantoniensis* as in the *Crocodilus Hastingsiæ*, and the alveolar border of the jaws describes the same sinuous course.

Had the complete fossil skull first submitted to my inspection at the meeting of the British Association at Oxford presented the same fossæ for the reception of the lower canines which exist in fig. 2, Pl. 1 *C*, I should have referred it to the Alligators,

notwithstanding the crocodilian characters of the small orbits, the long facial plates of the prefrontal and lachrymal, the wide supratemporal apertures, the non-expansion of the fore part of the palatines, and the non-appearance of the vomer on the palate, with other minor marks of the like affinity. For all these characters arise out of secondary modifications, and are presented in different degrees in the different species of *Crocodile,* and are rather of a specific than a generic value. They determine the judgment by the extent of their concurrence rather than by their individual intrinsic worth, and for that reason, therefore, the exposed position of the lower canine in the lateral groove of the upper jaw inclined the balance in favour of a reference of the previously-described fossil to the true Crocodiles. One cannot, indeed, attach any real generic importance to the modification of the upper jaw in relation to the lower canines. In three examples, however, in the collection of the Marchioness of Hastings, the crocodilian modification of this character is repeated, as it is shown in Pl. 1 *B,* fig. 1; and we have to choose, therefore, between the conclusion that Mr. Wood's specimen (Pl. 1 *C,* fig. 2) presents an accidental variety in this respect, or to view the fossæ in the upper jaw as indicative of not only a different species but a distinct genus from the *Crocodilus Hastingsiæ.* I should be glad to have more evidence on this point, and especially the opportunity of comparing the posterior nostrils, the orbits, the supratemporal apertures, and the occipital part of the skull of a specimen from Hordle, repeating the alligatorial character of the fossæ in the upper jaw for the lower canines. I am disposed to regard this character, notwithstanding its constancy in the living species of Alligator, as a mere variety in the Hordle fossil; but pending the acquisition of further evidence, it seems best to record this fossil under the title proposed for it by the able geologist by whom it was discovered.

Crocodilus Hastingsiæ. Plate 1 *D.*

Vertebræ referable to the Crocodilus Hastingsiæ.

The fossil crocodilian vertebræ obtained from the Eocene sand at Hordle, notwithstanding the comparatively limited extent of the researches in that interesting formation, are at least as abundant as those which have been discovered at Sheppy, but they do not, as at that locality, indicate two distinct species; all that have, hitherto, been found belong to one and the same kind of Crocodile, and from their robust proportions, would seem to have come from a species with a short and broad muzzle, like that of the Crocodile or Alligator, the fossil skulls of which have been described.

Perhaps the most perfect fossil reptilian vertebra that has hitherto been discovered is the one figured, of the natural size, in Pl. 1 *D,* figs. 1, 2, and 3. It is the fifth cervical vertebra. As compared with that of the *Crocodilus toliapicus* (Pl. 3 *A,* figs. 1, 2), which it resembles in size, the hypapophysis, *hy* (fig. 2, Pl. 1 *D*), is much more compressed, and the under part of the centrum is more extensively and deeply exca-

vated between it and the parapophyses (*p*); it is also excavated on each side behind the base of the hypapophysis, from which a progressively widening smooth ridge is continued to near the posterior surface of the centrum. The interspace at the side of the vertebra, between the parapophysis and diapophysis, is smaller but deeper in the *Crocodilus Hastingsiæ.* The neurapophyses meet above the centrum in both; but in the *Crocodilus Hastingsiæ* they are thicker anteriorly and thinner at their posterior border, and the neural canal (fig. 2, *n*) is more contracted than in the *Crocodilus toliapicus.*

As compared with the cervical vertebra of the *Crocodilus champsoïdes* from Sheppy, the present vertebra differs in the form of the hypapophysis in a greater degree than from the *Crocodilus toliapicus.* Fig. 8, Pl. 3 *A*, shows as little as does fig. 2 in the same plate, the median ridge and lateral excavations of the under part of the centrum which characterise the present vertebra of the *Crocodilus Hastingsiæ.* The *Crocodilus champsoïdes* resembles the *Crocodilus Hastingsiæ* in the character of the proportion and depression of that part of the side of the centrum forming the interspace between the parapophysis and diapophysis; but the antero-posterior extent of the parapophysis is relatively less in that Sheppy species. The outer surfaces of the neurapophyses in the *Crocodilus Hastingsiæ* slope or converge towards each other from before backwards, in a much greater degree than in either of the Sheppy species. I have not observed in any recent Crocodile or Alligator the median ridge, continued backwards from the hypapophysis and the lateral depressions, so strongly developed, as in the *Crocodilus Hastingsiæ.* The fore part of the neurapophyses is relatively thicker in this than in the recent species. The pleurapophyses *pl*, (figs. 1, 2), are well developed both forwards and backwards, and the latter productions are expanded and excavated above for the reception of the fore part of the succeeding cervical rib. The zygapophyses (*z*) are thicker at their base, especially the hinder pair, where the base fills up the entire interval between the articular surface and the base of the spine (see fig. 2). There is the usual deep excavation at the fore and back part of the base of the spine (*ns*) for the insertion of the interspinal ligaments. The neural spine is compressed, moderately long, straight and truncate at its summit.

Although the hypapophysis maintains its characteristic form with much constancy in the homologous vertebræ of the same species of Crocodile, it varies in different cervical vertebræ of the same individual in certain existing species. It is, for example, shorter and thicker in the third and fourth vertebræ than in the succeeding ones in the *Crocodilus acutus;* whilst in the *Crocodilus biporcatus* the hypapophysis of the third cervical is more compressed than that of the sixth. The greatest difference is, however, presented, as far as I have yet made the comparison, by the cervical vertebræ of the *Alligator lucius,* in respect of the hypapophysis, which is broad and short in the third and fourth cervicals, but becomes long and slender in the succeeding cervicals. The small vertebral centrum (fig. 4, Pl. 1 *D*) resembles, in its broad and stunted

hypapophysis, that of the third cervical vertebra of the Alligator, but with an indication of a median rising and lateral depressions, behind that process, like those which are more decisively shown in the fifth cervical vertebra of the larger individual of the *Crocodilus Hastingsiæ*, to which species I believe the specimen fig. 4 to belong. It is the homologous vertebra with fig. 8, Pl. 3 *A*, and well illustrates the different proportions of the bones in different species of Crocodile.

Fig. 6 gives a view of the anterior surface of the first sacral vertebra of the *Crocodilus Hastingsiæ:* the under surface of the centrum has ceased to develope the median ridge; the short and thick ribs (*pl*) have completely coalesced with both the centrum and neural arch. The anterior concavity has a fuller and more exact elliptical form than that of the *Crocodilus toliapicus* (fig. 5, Pl. 3 *A*); the anterior zygapophyses do not project over the rim of that concavity; but, like those of the Alligator and Crocodile, they are more transversely extended than in the Gavial.

The general proportions of the first caudal vertebra (fig. 7, Pl. 1 *D*) are intermediate between those of the *Crocodilus toliapicus* (fig. 7, Pl. 3) and of the *Crocodilus champsoïdes* (fig. 10, Pl. 3 *A*): the under surface of the centrum is flat, not concave, lengthwise, as in both the Sheppy Crocodiles; the side of the centrum is irregularly tuberculate, not smooth, and concave lengthwise; the broad and high neural spine is deeply grooved at its fore part: a smaller proportion of the hinder end of the centrum (fig. 5) is occupied by the articular ball than we find in the antecedent vertebræ.

As none of the other numerous vertebræ and portions of vertebræ give any indications of a different species from the *Crocodilus Hastingsiæ*, or add any material characters to those of that species which have been deduced from the parts of the skeleton already described, I refrain from trespassing on the reader's attention or occupying further space by their description or figures.

Genus—GAVIALIS, Oppel.

GAVIALIS DIXONI, *Owen*. Plate 3 *B*.

The characters of the genus *Gavialis* are much more strongly marked than are those which distinguish the Alligators from the Crocodiles, and leave no ambiguity in the conclusions that may be deduced from them. The present interesting addition to the catalogue of British Fossil Reptiles, is due to the discovery in the Eocene deposits at Bracklesham, by my lamented friend the late Frederic Dixon, Esq., F.G.S., of the remains figured in Pl. 3 *B*. The portions of the lower jaw demonstrate, by the slender proportions of the mandibular rami (figs. 1, 5), the extent of the symphysis, the uniform level of the alveolar series, and the nearly equal distance of the sockets of the comparatively small, slender, and equal-sized teeth, the former existence in England, during the early tertiary periods, of a Crocodilian with the maxillary and dental

characters of the genus *Gavialis.* These characters are, however, participated in by some of the extinct Crocodilians of the secondary strata (see Pl. 1, fig. 2′); but in them they coexist with a different type of vertebra from that of the recent and known tertiary Crocodilian genera: it became necessary, therefore, to ascertain what form of vertebra might be so associated with the fossil Gavial-like jaws and teeth in the Bracklesham Eocene deposits, as to justify the conclusion that such vertebræ had belonged to the same species as the jaws. Now, the only Crocodilian vertebræ that have yet been found at Bracklesham, so far as I can ascertain, present the procœlian type of articular surfaces of the body (Pl. 3 *B*), like that in Mr. Dixon's collection fig. 8. This vertebra answers to the fifth cervical vertebra in the existing Crocodilians, and accords in its proportions with that in the Gangetic Gavial. There are a few indications of specific distinction; the parapophysis (*p*) or lower transverse process articulating with the head of the rib, is relatively shorter antero-posteriorly. The broad, rough, neurapophysial sutures (*n*) meet upon the middle of the upper part of the centrum; the elsewhere intervening narrow neural tract sinks deeper into the centrum than in the modern Gavial, but is perforated, as in that species, by the two approximated vertical vascular fissures. The hypapophysis (*hs*) or process from the inferior surface of the centrum, has been broken off in the fossil, but it accords in its place and extent of origin with that in the fifth and following cervical vertebræ of the Gavial. Assuming the fossil procœlian vertebræ from Bracklesham, and the above-described vertebra in particular, to have belonged to the same individual or species as the portions of fossil jaw (figs. 1, 5), then these mandibular and dental fossils must be referred to the genus *Gavialis,* or to the long-, slender-, and subcylindrical-snouted *Crocodilia* with procœlian vertebræ.

This genus is now represented by one or two species peculiar to the great rivers of India, more especially the Ganges; and the fossil differs from both the *Gavialis gangeticus,* Auct., and from the (perhaps nominal) *Gavialis tenuirostris,* Cuv., in the form and relative size of the teeth. The crown (figs. 6, 7) is less slender in the fossil than in the existing Gavials, and less compressed, its transverse section being nearly circular. There are two opposite principal ridges, but they are less marked than in the existing Gavials; and are placed more obliquely to the axis of the jaw, i. e., the internal ridge is more forward, and the external one more backward, when the tooth is in its place in the jaw. In the modern Gavial, the opposite ridges, besides being more trenchant, are nearly in the same transverse line. The other longitudinal ridges on the enamel of the fossil teeth, are more numerous, more prominent, and better defined, than in the existing Gavials: the intermediate tracts of enamel present the same fine wrinkles in the fossil as in the existing Gavials' teeth.

The two chief portions of jaw (fig. 1, and figs. 4, 5) belong to two individuals of different ages; indicated by the difference in the breadth and depth of the ramus: both specimens being from the corresponding part of the jaw, viz. where it forms the

long symphysis characteristic of the Gavials. The specimen (figs. 4, 5) includes a larger proportion of the jaw than the fragment delineated in fig. 1.

On comparing the latter fragment of the fossil lower jaw with a specimen of a lower jaw of the *Gavialis gangeticus* of the same breadth across the symphysial part, at the intervals of the sockets, which breadth is 3 centimeters (1 inch 3 lines), I find that the longitudinal extent of 10 centimeters (near 4 inches) of a ramus of the fossil jaw includes five sockets; but in the recent Gavial the same extent of jaw includes seven sockets, showing that the teeth are fewer as well as larger in the fossil Gavial, in proportion to the breadth of the jaws.

The second portion of the jaw (fig. 2) is from the part where the rami diverge posteriorly from the symphysis, and near the posterior termination of the dentary series. Here the teeth become shorter in proportion to their thickness, and somewhat closer placed together: there is a shallow depression (*c*) in each interspace of the teeth, for the reception of the crowns of the opposite teeth when the mouth is shut. These depressions are longer, deeper, and better defined in the fossil than in the recent Gavial of the same size.

The fragments of jaw and teeth of the fossil Gavial of Bracklesham show examples of young teeth penetrating the base of the old ones, according to the law of succession and shedding of the teeth, which characterises the existing *Crocodilia:* fig. 2 shows the apex of one of the successional teeth at *d*; and fig. 3 *d* the hollow base of the same incompletely formed tooth seen from below.

Besides the fossil jaws, teeth, and vertebræ of the extinct Gavial, a nearly entire femur (fig. 9) of a Crocodilian has been discovered in the Eocene deposits at Bracklesham, which in its proportions, agrees with that bone in the Gavial of the Ganges. Cuvier, in his comparison of the bones of the Gavial with those of the Alligators and true Crocodiles, merely observes, "La forme des os du Gavial ressemble aussi prodigieusement à celle des os du Crocodile, seulement les apophyses épineuses des vertèbres sont plus carrées."*

With regard to the femur, this bone is more slender in proportion to its length in the Gangetic Gavial, than in the *Crocodilus biporcatus* or the *Alligator lucius,* and the anterior convex bend of the shaft commences nearer the head of the bone; and in these characters the fossil femur from Bracklesham corresponds with the modern Gavial, and differs from the Crocodiles and Alligators, and also from the *Crocodilus Hastingsiæ*, of which species specimens of the fossil femur have been kindly submitted to me by the Marchioness of Hastings and Alexander Pytts Falconer, Esq. The fossil femur of the Gavial from Bracklesham (fig. 9) may therefore be referred, with the utmost probability, to the same species as the portions of jaw, teeth, and vertebræ above described; and as these clearly demonstrate a species distinct from any known Gavial, I propose to call the extinct species of the Eocene deposits at Bracklesham, *Gavialis Dixoni,* after

* Ossemens Fossiles, 4to, tom. v, pt. ii, p. 108.

my esteemed friend, by whose scientific and zealous investigations so much valuable additional knowledge has been obtained respecting the fossils of that rich, but, previously to his researches, little known locality.

The tooth represented of the natural size in fig. 10, Pl. 3 *B*, was also discovered at Bracklesham, and forms part of the collection of G. Coombe, Esq. It resembles, in its proportions and obtuse extremity, the teeth of the Crocodiles rather than those of the Gavials, and at first sight reminded me of those of the *Goniopholis* or amphicœlian Crocodile of the Wealden period. On comparing it closely with similar-sized teeth of that species, the enamel ridges were more numerous and decided in the *Goniopholis;* and the delicate reticular surface in the interspaces of the more widely separated and feebler longitudinal ridges in the Bracklesham tooth was wanting in the *Goniopholis.* The minute superficial characters of the enamel of the large and strong Crocodilian tooth from Bracklesham, closely agree with those of the *Gavialis Dixoni.* It is just possible that this may be a posterior tooth of a very large individual of that Gavial, as the teeth become at that part of the jaw shorter in proportion to their thickness in the modern Gavials. If it should not belong to that Gavial, it must be referred to a Crocodile distinct from those species of the secondary strata, or those existing Crocodiles which have teeth of a similar form; since they present a different superficial pattern of markings on the enamel.

On reviewing the information which we have derived from the study of the fossil remains of the procœlian *Crocodilia*, that have been discovered in the Eocene deposits of England, the great degree of climatal and geographical change, which this part of Europe must have undergone since the period when every known generic form of that group of reptiles flourished here, must be forcibly impressed upon the mind.

At the present day the conditions of earth, air, water, and warmth, which are indispensable to the existence and propagation of these most gigantic of living Saurians, concur only in the tropical or warmer temperate latitudes of the globe. Crocodiles, Gavials, and Alligators now require, in order to put forth in full vigour the powers of their cold-blooded constitution, the stimulus of a large amount of solar heat, with ample verge of watery space for the evolutions which they practise in the capture and disposal of their prey. Marshes with lakes, extensive estuaries, large rivers, such as the Gambia and Niger that traverse the pestilential tracts of Africa, or those that inundate the country through which they run, either periodically, as the Nile for example, or with less regularity, like the Ganges; or which bear a broader current of tepid water along boundless forests and savannahs, like those ploughed in ever-varying channels by the force of the mighty Amazon or Oronooko;—such form the theatres of the destructive existence of the carnivorous and predacious Crocodilian reptiles. And what, then, must have been the extent and configuration of the eocene continent which was drained by the rivers that deposited the masses of clay and sand, accumulated in some parts of

the London and Hampshire basins to the height of one thousand feet, and forming the graveyard of countless Crocodiles and Gavials? Whither trended that great stream, once the haunt of Alligators and the resort of tapir-like quadrupeds, the sandy bed of which is now exposed on the upheaved face of Hordwell Cliff?

Had any of the human kind existed and traversed the land where now the base of Britain rises from the ocean, he might have witnessed the Gavial cleaving the waters of its native river with the velocity of an arrow, and ever and anon rearing its long and slender snout above the waves, and making the banks re-echo with the loud and sharp snappings of its formidably-armed jaws. He might have watched the deadly struggle between the Crocodile and Palæothere, and have been himself warned by the hoarse and deep bellowings of the Alligator from the dangerous vicinity of its retreat. Our fossil evidences supply us with ample materials for this most strange picture of the animal life of ancient Britain, and what adds to the singularity and interest of the restored 'tableau vivant,' is the fact that it could not now be presented in any part of the world. The same forms of Crocodilian Reptile, it is true, still exist, but the habitats of the Gavial and the Alligator are wide asunder, thousands of miles of land and ocean intervening: one is peculiar to the tropical rivers of continental Asia, the other is restricted to the warmer latitudes of North and South America; both forms are excluded from Africa, in the rivers of which continent true Crocodiles alone are found. Not one representative of the Crocodilian order naturally exists in any part of Europe; yet every form of the order once flourished in close proximity to each other in a territory which now forms part of England.

Order—Lacertilia.

Pleurodont Lizard. Plate 3 (*Ophidians*), figs. 43, 44.

Although members of the present order, with the modern procœlian type of vertebræ, existed in England during the Wealden and Chalk periods, and the greater part of the actual class of Reptiles, in all parts of the world, is composed of the same order, yet but one solitary example of true Lacertian from the formations of the Eocene tertiary period has hitherto come under my observation—a fact which has often excited my surprise. Future researches may bring to light farther and better evidence of the class.

Among the fossils obtained by Mr. Colchester from the Eocene sand, underlying the Red Crag at Kyson, or Kingston, in Suffolk, the existence of a Lizard, about the size of the Iguana, is indicated by a part of a lower jaw, armed with close-set, slender, subcylindrical, antero-posteriorly compressed teeth, attached to shallow alveoli, and with their bases protected by an external parapet of bone. The fragment of jaw is traversed by a longitudinal groove on the inside (fig. 44), and is perforated, as in most modern Lizards, by numerous vascular foramina along the outside (fig. 43). The teeth are hollow at their base.

CHAPTER III.—Order *OPHIDIA.*

SERPENTS.

Prior to the publication of my Memoir on the *Palæophis* in the 'Geological Transactions,'* and my 'Report on British Fossil Reptiles,'† the sole notice of any fossil belonging to the order of Serpents was contained in the following passage from the Appendix to the concluding volume of the second edition of Baron Cuvier's great and comprehensive work, the 'Recherches sur les Ossemens Fossiles.' After alluding to the scarcity of the fossil remains of birds, the immortal author of that work proceeds to say: "The bones of Serpents are still rarer, if it be possible. I have seen no specimens of them, save the vertebræ from the osseous breccia of Cette, of which I have spoken in the article on those breccia, and a single one from the fresh-water deposits of the Isle of Sheppy."‡

We may perhaps gather the reason for the silence of Cuvier respecting the relations of that vertebra and of the fossil vertebræ of Serpents in general to each other, and to those of the existing species, from his brief notice of the Ophidian fossils from the breccia of Cette; where, after stating in general terms their resemblance in form and figure to the vertebræ of the common harmless snake (*Coluber natrix*), he proceeds to remark, "but it may well be conceived, that in a genus where the osteology of the species has so much similitude, it is not in isolated vertebræ that one can discover specific characters."§ If, however, this discouraging conclusion of the great comparative anatomist should be countenanced by the results of a rigorous comparison of the vertebræ of the different species of *Coluber*, as that genus may be restricted by modern naturalists, it is by no means borne out by such comparison of the vertebræ of the species of the wider Linnean genus *Coluber*, and gives place to a very different estimate of the value of vertebral characters, when these are studied in species of the different Linnean genera of the '*Amphibia* Serpentes' in the 'Systema Naturæ.'

Baron Cuvier having, conformably with his convictions, deemed it unnecessary to give figures or to describe the vertebræ of Serpents, recent or fossil, in his 'Ossemens Fossiles,' I am compelled to premise such observations on the anatomical construction of this part of the skeleton of those Reptiles as will render intelligible my description

* Vol. vi, 2d series (1839), p. 209, pl. xxii.

† Report of the British Association for the Advancement of Science, for 1841.

‡ "Les os de serpens sont encore plus rares, s'il est possible. Je n'en ai vu que des vertèbres des brèches osseuses de Cette, dont j'ai parlé à l'article de ces brèches, et une seule des terrains d'eau douce de l'île de Sheppy." (Tom. v, pt. ii, p. 526, 1824.)

§ "Mais on sent bien que, dans un genre ou l'ostéologie des espèces a tant de ressemblance, ce n'est pas dans les vertèbres isolées que l'on peut trouver les caractères spécifiques." (Op. cit., tom. iv, p. 180.)

of the fossil ophidian vertebræ, and vindicate the grounds on which some of these are referred to distinct species, and others to genera of which we have no evidence of the actual existence in living Nature.

I have selected as the type of an ophidian vertebra that of a large, terrestrial, constricting Serpent (*Python Sebæ*), an African species, which makes the nearest approach in size to some of the fossil ophidian vertebræ from British tertiary strata. The vertebra figured in Pl. 2, figs. 1-4, is from about the middle of the back of a specimen which was twenty feet in length. In the Pythons, as in other known *Ophidia*, all the autogenous elements, except the pleurapophyses (*pl*, figs. 2′, 3′), coalesce with one another in the vertebræ of the trunk; and the pleurapophyses (Pl. 3, fig. 42, *pl*) also become anchylosed to the diapophyses (ib. *d*) in those of the tail. There is no trace of suture between the neural arch (Pl. 2, figs. 1-4 *n*) and centrum (*c*). The outer substance of the vertebra is compact, with a smooth or polished surface. The vertebræ are procœlian, the cup (fig. 2 *c*) being deep, with its rim sharply defined and most produced at the sides; the cavity looking not directly forwards, but a little downwards, from the greater prominence of the upper over the lower border: the well-turned prominent ball (fig. 3 *c*) terminates the back part of the centrum rather more obliquely, its aspect being backwards and upwards. The hypapophysis (*h*) is developed in different degrees from different vertebræ, but throughout the greater part of the trunk presents the form and proportions shown in figs. 1, 4 *h*. A vascular canal perforates the under surface of the centrum (fig. 4), and there are sometimes two or even three smaller foramina. A large, vertically oblong, but short diapophysis (*d*) extends from the fore part of the side of the centrum obliquely upwards and backwards. It is covered by the articular surface for the rib, which is convex lengthwise, and convex vertically at its upper half, but slightly concave at its lower half. The base of the neural arch swells outward from its confluence with the centrum, and developes from each angle a transversely elongated zygapophysis; that from the anterior angle (*z*) looking upwards, that (*z′*) from the posterior angle downwards, both surfaces being flat, and almost horizontal. A thick rounded ridge connects the anterior with the posterior zygapophysis on each side, extending along the base of the neural arch. The neural canal (fig. 2, *n*) is narrow, with a subtriedral area, and with a narrow longitudinal ridge on each side. The neural spine (*ns*) is of moderate height, which scarcely equals its antero-posterior extent; it is compressed and truncate. A wedge-shaped process—the 'zygosphene'* (*zs*, fig. 2)—is developed from the fore part of the base of the spine; the lower apex of the wedge being, as it were, cut off, and its sloping sides presenting two smooth, flat, articular surfaces. This wedge is received into a cavity—the 'zygantrum'† (fig. 3, *za*)—excavated in the posterior expansion of the neural arch, and having two smooth articular surfaces to which the zygosphenal surfaces are adapted.

* Ζῦγόν, a yoke, σφήν, a wedge.

† Ζῦγόν, and ἄντρον, a cavity.

Thus the vertebræ of Serpents articulate with each other by eight joints in addition to those of the cup and ball on the centrum; and interlock by parts reciprocally receiving and entering one another, like the joints called tenon-and-mortise in carpentry.

This is the most conspicuous, but is not the peculiar characteristic of an ophidian vertebra; the zygosphene (*zs*) and zygantrum (*za*) being developed in certain Lacertians, e. g. the genus *Iguana* (Pl. 2, figs. 34, 35), but here the articular diapophysis (fig. 33, *d*) is much smaller, and forms a simple, convex, sessile tubercle; the hypapophysis is wanting: the zygosphene (fig. 34, *zs*) is deeply notched anteriorly, and the zygantra (fig. 35, *za*, *za*) are shallow, and separated from each other behind: a thick rounded eminence extends backwards from the diapophysis to the ball on the back part of the centrum (fig. 36); and that ball is a transverse ellipse (fig. 35), not hemispheroid, as in the *Ophidia*.

With regard to the specific distinctions which may be deduced from the characters of the vertebræ of Serpents, it is requisite first to determine the extent to which those characters vary in the vertebral column of the same species.

The atlas and axis are modified in the same degree as in the *Crocodilia*, with the addition of the entire suppression of their pleurapophyses. The atlas (Pl. 3, figs. 38, 39) has two hypapophyses, one behind the other, as we shall find to be the case in other vertebræ of one of the great fossil Serpents. The normal hypapophysis (*h*, fig. 39), answering to that marked *ca*, *ex* in the woodcut, fig. 8, p. 85, is autogenous and wedge-shaped, as usual in the Reptilia; and is articulated on each side to a small portion of the neurapophysis (*n*); it also presents a concave articular surface anteriorly (fig. 38, *h*) for the lower part of the basioccipital tubercle, and a similar surface behind for the detached central part of the body of the atlas (fig. 40, *ca*), which is here confluent with that of the axis (fig. 40, *cx*), forming the so-called odontoid process of that vertebra; its Ophidian peculiarity being the development of an exogenous hypapophysis (*h'*) from its under and back part, like the posterior hypapophysis of the succeeding vertebræ.

The base of each neurapophysis of the atlas (fig. 38, *n*) has an antero-internal articular surface for the exoccipital tubercle, and a postero-internal surface for the upper and lateral parts of the odontoid (*ca*), besides the small median inferior facet for the detached hypapophysis (*h*): they thus rest on both the separated parts of their proper centrum. The neurapophyses expand and arch over the neural canal, but meet without coalescing. There is no neural spine. Each neurapophysis developes from its upper and hinder border a short zygapophysis (*z*): and from its side a still shorter diapophysis (*d*).

The axis or second vertebra of the trunk with the partially coalesced body of the atlas or 'odontoid,' is represented at fig. 40, Pl. 3.

The odontoid presents a convex tubercle anteriorly, which fills up the articular cavity in the atlas for the occipital tubercle: below this is the surface for the detached

hypapophysial part of the atlas (fig. 39, *h*) and above and behind it are the two surfaces for the atlantal neurapophyses; the whole posterior surface of the odontoid is anchylosed to the proper centrum of the axis.

The neural arch of the axis developes a short ribless diapophysis from each side of its base; a short zygapophysis (*z*), from each side of its anterior border; a thick sub-bifid zygapophysis (*z′*) from each side of the posterior border, and a moderately long retroverted spine (*ns*) from its upper part. The centrum terminates in a ball behind, and below this sends downwards and backwards a long hypapophysis (*hx*).

In the skeleton of an African Constrictor (*Python regius*, Dum.), which measured 15 feet 6 inches in length, there are 348 vertebræ, of which the 279 following the atlas and axis support simple moveable ribs; of these vertebræ about 70 anterior ones have long hypapophyses, as in fig. 4, *h*, Pl. 3, which in the rest subside to the obtuse ridge and tubercle, as in fig. 1, *h*, Pl. 2: the caudal vertebræ have not the ribs moveably articulated; they are 67 in number; of these vertebræ 56 have bifurcate hypapophyses as in fig. 42, *h*, Pl. 3; the six anterior caudals have bifurcate ribs (Pl. 3, fig. 41, *pl*), in the rest they are simple (Pl. 3, fig. 42, *pl*), and lengthen out the diapophyses (ib. *d*,) to which they are anchylosed.

The ribs of the trunk-vertebræ, like those of the tail, are 'pleurapophyses' or 'vertebral ribs;' there are no 'hæmapophyses' or sternal ribs; the exogenous hypapophyses (*h*, fig. 42) take the place of the hæmapophyses in the tail. The pleurapophyses of the trunk (Pl. 2, figs. 2′, 3′), are long, slender, curved, subcompressed, expanded at the proximal end, which presents an articular surface chiefly concave, and adapted to the diapophysial tubercle (*d*, figs. 2, 3,) above described; there is a rough depression on the fore part of the expansion for the insertion of a ligament, and a tuberosity projects from the upper and back part; the distal end of the rib is truncate, with a terminal pit; a medullary cavity extends through a great part of the length of the rib, as shown in fig. 3″, Pl. 2.

There is a small cavity in the substance of each neurapophysis, which communicates by a smaller foramen with the zygantrum. A vascular cavity in the centrum communicates with the neural canal.

In the skeleton of a Tiger-boa (*Python tigris*), in the Museum of the Royal College of Surgeons, measuring eleven feet in length, and having 291 vertebræ, the 253 following the axis support simple moveable pleurapophyses, articulated to concavo-convex sessile diapophyses, and constitute the dorsal, abdominal, or trunk-vertebræ; 70 of the anterior of these vertebræ have long hypapophyses, as in fig. 4, *h*, Pl. 3, they then begin to shorten, and subside to the ridge and tubercle, as shown in fig. 1 and 4, Pl. 2, in the rest of the trunk-vertebræ. The first caudal vertebra has free pleurapophyses, but they are short and bifurcate, the upper prong being the shortest; in the second caudal the left bifurcate rib is free, but the right is anchylosed to the diapophyses; the prongs are of equal length in this and the two following vertebræ.

In the fifth caudal the outer prong is again shorter, and in the sixth it is a mere tubercle; at this part of the tail the hypapophyses begin to lengthen, bifurcate, and progressively increase in length to the sixteenth caudal, and thence gradually diminish and subside; yet the general configuration of the neural arch, the contour and degree of production of its posterior border, and the shape of the zygosphene, remain almost unaltered throughout.

In a true *Boa constrictor*, with 305 vertebræ, 71 at the anterior part of the trunk have long hypapophyses; and of the 60 caudal vertebræ, 44 have bifid hypapophyses. The first caudal is characterised by the sudden shortening of its ribs, and by a short process from the middle of their outer surface: this process is longer and nearer the head in the next rib; and in the third caudal vertebra the rib seems to bifurcate from its proximal end, which has become anchylosed to the diapophysis. Beyond the eighth caudal the outer costal prong or process disappears, and the anchylosed rib represents a long deflected diapophysis to within three or four vertebræ from the end of the tail. The last imperforate obtuse bone of the tail is obviously a coalescence of three vertebræ.

In the Rattlesnake (*Crotalus*, Pl. 2, figs. 9-12) the hypapophyses (*h*) continue to be developed singly, and of equal length with the neural spines (*ns*), throughout the trunk; and any single vertebra might be distinguished from an anterior trunk-vertebra of a *Boa* or *Python* by the following characters: the diapophysis (*d*) developes a small, circumscribed, articular tubercle from its upper convexity, and a short process (*d'*) from its under part, extending downwards and forwards below the level of the centrum (*c*); the anterior zygapophysis (*z*) seems to be supported by a similar process (*d''*) from the upper end of the diapophysis, the point of which projects a little beyond the end of the zygapophysis (fig. 10); the zygapophyses are less produced outwards than in the Python; the zygantra (*za*, fig. 11) are more distinct excavations.

In the Cobra di Capello (*Naja*, Pl. 2, figs. 13-16), the diapophysis presents the same well-marked tubercle (*d*) upon its upper part, but its lower end (*d'*) is much less produced than in the Rattlesnake; the process of bone (*d''*) underpropping the zygapophysis projects proportionally further beyond the articular surface (*z*): the neural spine (*ns*) is much lower, and beyond the anterior third of the trunk the hypapophysis (*h*) subsides into a ridge, with its point produced backwards beneath the articular ball of the centrum; the zygantra (*za*, fig. 15) are distinct cavities.

In the *Coluber elaphus* (Pl. 2, figs. 17-20) the trunk-vertebræ are distinguished by the great extent to which the part of the diapophysis (*d''*, fig. 18) which underprops the zygapophysis (*z*) is produced beyond the articular surface, the lower end of the diapophysis (*d'*) is less produced; the hypapophysis, beyond the anterior fourth part of the vertebral column, is reduced to a straight ridge, (fig. 20, *h*), extending along the middle of the under surface of the centrum, and not produced posteriorly: a groove separates the ridge on each side from the diapophysis and the posterior ball of the centrum. Both the cup and ball and the articular part of the diapophysis are relatively

smaller than in the *Naja;* the neural spine (*ns*, fig. 17) is lower in proportion to its antero-posterior extent. The pleurapophysis (*pl*) is shown articulated to the tubercle in figs. 19 and 20.

The vertebræ of the common harmless Snake, *Coluber natrix*, differ only in size from those of the larger continental species above described.

In an African *Eryx* (Pl. 2, figs. 21-24) the diapophysis (*d*) does not extend beyond the articular surface of the anterior zygapophysis (*z*), but is exclusively devoted to forming a low, subconvex, articular tubercle, which has a longitudinal depression anteriorly; the posterior margin of the neurapophysis (fig. 21, *n*) forms an angle above the zygantrum, which angle, though slight, is more marked than in any of the foregoing Ophidians; the hinder end of the hypapophysial ridge (*h*) is slightly produced; the zygapophyses (*z*, *z*′, fig. 24) are less extended outwards than in the Pythons.

In a Sea-snake (*Hydrophis bicolor*, Pl. 2, figs. 25-28) I find the height of the neural spine (fig. 25, *ns*) greater in proportion to its antero-posterior extent than in any of the foregoing Ophidians. The diapophysis (*d*) sends a point (*d*″) outwards a little beyond the articular surface of the anterior zygapophysis (*z*); a very small hypapophysis (*h*) projects below the articular ball of the centrum, and a low ridge is continued forwards from it (fig. 28); the posterior border of the neurapophysis (fig. 25, *n*) forms no angle, but is moderately convex, as in all the foregoing Ophidians, excepting the *Eryx*.

With this indication of the kind and extent of the vertebral characters of the different species of Serpent which I have been able to study in reference to the fossils to be described, I proceed to the comparisons by which the following extinct genera and species have been established.

Genus—PALÆOPHIS.

PALÆOPHIS TYPHÆUS, *Owen*. Plate 2, figs. 5-8, Plate 3, figs. 1-3, 7-9, 16, 17, 26, 27, 28. (Fig. 6, 10-12?)

Amongst the numerous vertebræ of this species of Serpent which have come under my examination, a few, of small size, have shown the hypapophysis long and compressed, as in the specimen in Mr. Bowerbank's collection, figured in Pl. 3, figs. 1-3, *h*, indicating that the vertebræ at the anterior part of the trunk had that character, as in the large existing Serpents; whilst all the larger vertebræ, with the hypapophysis perfect, manifest shorter proportions of that process, as in the typical example, apparently from the middle of the abdomen (Pl. 2, figs. 5-8, *h*); whence I infer that the *Palæophis* resembled the *Python*, *Boa*, *Coluber*, and *Hydrus*, in having different proportions of the hypapophysis at different parts of the vertebral column. Had every fossil vertebra shown a long hypapophysis like that in Pl. 3, fig. 1, we might have suspected that the species had been of the venomous family, like the Rattlesnake.

The veritable Ophidian nature of the fossils in question is demonstrated, not only

by the superadded zygosphenal (*zs*, fig. 6) and zygantral (*za*, fig. 7) articulations, but by the solidity of the zygosphene, by the size and form of the centrum, by those of its articular cup (*c*, fig. 6) and ball (*c*, fig. 7), and of its hypapophysis (*h*); and also by the size and prominence of the diapophysis (*d*). The largest vertebræ (e. g. Pl. 2, figs. 5-8, and Pl. 3, figs. 16, 26, 27, 28) probably from about the middle of the body, as compared with the vertebræ from the same part of the skeleton of a *Python Sebæ*, twenty feet in length, are longer in proportion to their breadth, and the cup and ball of the centrum are larger; the hypapophysis (*h*) is more produced, and there is a second smaller hypapophysis close to the anterior part of the under surface of the centrum, which in most of the large vertebræ is connected by a ridge with the hinder and normal hypapophysis; but in a few vertebræ is not so connected. The articular cup and ball are less obliquely placed upon the extremities of the centrum, being nearly vertical (compare fig. 5 and fig. 1, *c'*). The rim of the cup is sharply defined, and is more produced from between the bases of the diapophyses; a deeper and narrower chink intervening than in the *Python*. The transverse diameter of the cup (*c*, fig. 6) is greater than that of the zygosphene (ib., *zs*)—a proportion which I have not found in the vertebræ of any existing genus of Serpent, in which the base of the zygosphene always equals at least the parallel diameter of the articular cup. The articular part of the diapophysis is more produced outwards and less extended vertically in *Palæophis* than in *Python*, and it is uniformly convex; a ridge is continued from its upper end obliquely forwards to, but not beyond, the apex of the anterior zygapophysis (*z*), forming the angle between the lateral and anterior surfaces, whilst the horizontal articular facet forms the third surface of that three-sided conical process. In the Python the non-articular part of the same zygapophysis is convex, and the process is much more extended outwardly; the proportions of the zygapophysis in the *Palæophis* more resemble those in the *Coluber* and *Hydrus*, but differ from these, as also from *Naja* and *Crotalus*, in the non-extension of the diapophysial point beyond the articular surface.

A ridge or horizontal rising of the bone extends from the anterior to the posterior zygapophysis, but is more or less blunted or subsides midway, and is by no means so produced outwards as in Python; in this respect more resembling that in *Coluber* and *Hydrus*. Below the middle of this ridge, on a level with the upper surface of the centrum, there is a short, nearly parallel rising in *Palæophis* (fig. 5). The zygosphene (fig. 6, *zs*) is slightly excavated anteriorly, and shows no trace of the tubercle which characterises the middle of that surface in the Python (fig. 2); it is also broader in proportion to its height. But perhaps the most characteristic feature of the vertebra of the *Palæophis* is the peculiar production of the posterior border of the neurapophysis into an angle (*n*, fig. 5) directed upwards, outwards, and backwards, and this is common to all the species; there is no trace of this process in the *Hydrus* (fig. 25), and the nearest approach to it which I have hitherto met with among existing

Serpents, is that low, tuberous angle at the corresponding part of the vertebra of the *Eryx* (fig. 21). The posterior zygapophysis resembles, of course, the anterior one in its much less extent, especially transversely, as compared with that in the Python, and the posterior border of the neurapophysis (fig. 5, *z′*, *n*) rises from its apex vertically, or a little inclined outwards and backwards, giving a squarish form to the surface of the neural arch in which the zygantra (*za*, fig. 7) are excavated; these cavities, in proportion to the articular ball beneath, are smaller and less deep than in the Python, or any other existing genus of Serpent. The sloping sides of the neural arch above the zygapophysial ridge are more concave than in Python, and so resemble those parts in *Coluber* and *Hydrus*. The latter genus (fig. 25) and *Crotalus* (fig. 9) most resemble *Palæophis* in the proportions of the neural spine (*ns*); this part, however, in *Palæophis* differs from that of *Hydrus* in having its base coextensive with the supporting arch, springing up from the fore part of the zygosphene, whilst this part entirely projects forwards, clear of the base of the spine in *Hydrus*, as in *Python*, *Coluber*, and *Naja*; but in *Crotalus* the base of the spine has the same antero-posterior extent as in *Palæophis*, and it comes very near to the fore part of the zygosphene in *Eryx*. The neural spine has been more or less fractured in every specimen of the brittle crumbling vertebræ of the *Palæophis Typhæus* from the Bracklesham Clay; only one specimen, which I carefully worked out in relief from a mass of matrix, after imparting some of its original tenacity to the substance of the bone, affords a true idea of the peculiar character of these Ophidian vertebræ, which is afforded by the great height of the neural spine (see Pl. 3, fig. 27, *ns*); but even here, although the fore part of the spine equals in vertical extent that of the rest of the vertebra beneath it, I am not sure that its entire extent is preserved, the part having been obliquely broken away behind this point before the specimen came into my hands. Some vertebræ of another species of *Palæophis* from Sheppy, show this elevated spine to be a generic characteristic of the fossil vertebræ.

	Inches.	Lines.
The entire vertical extent of the vertebra, fig. 27, from the end of the hypapophysis to the summit of the neural spine is .	2	5
The length of the same vertebra is	1	2
The length of a larger vertebra of the same species . .	1	4
The length of the smallest free vertebra	0	5

I have specified this last vertebra as being 'free,' because in Mr. Dixon's collection, by far the richest in the remains of the great *Palæophis* of Bracklesham, there are two smaller vertebræ anchylosed together by both their bodies and neural arches (Pl. 3, figs. 32, 33, 34), which, therefore, are not 'atlas and axis,' but from their compressed form I should judge rather to have come from the opposite end of the vertebral column: they have not formed, however, the very extremity of the tail, like the terminal anchylosed vertebræ in the *Boa constrictor*, or those supporting the rattle

in the *Crotalus;* for the ball of the centrum, the posterior zygapophyses, and the zygantral articulations, are present on the back part of the second of these anchylosed vertebræ. But before further pursuing the description of this remarkable specimen, I shall premise a brief notice of the vertebræ which have presented other modifications.

In the series of Palæophidian vertebræ from Bracklesham, which I have had the opportunity of comparing, a few, as has been already remarked, appear to have come from the fore part of the body by the length of the hypapophysis, as compared with the size of the vertebræ, which is small; a character that adds to the likelihood of their having come from that extremity of the series. Fig. 1, Pl. 3, shows one of these vertebræ in which the hypapophysis (*h*) is entire; it is shorter and much more compressed than that process is in the anterior trunk-vertebræ of the Python, fig. 4, and its base extends forwards, as a sharp ridge, to between the diapophyses (fig. 3), where like them, it has been mutilated by fracture. The zygapophyses are small, and there is no ridge continued from the anterior to the posterior one; the neurapophysis presents the characteristic angular production (fig. 1, *n*), and the neural spine (ib. *ns*) is coextensive with the supporting arch.

The second form of vertebra is characterised by a single and moderately-developed hypapophysis, the base of which is confined to the hinder half of the under surface of the centrum, leaving the fore part of that surface concave where it expands between the bases of the diapophyses. I have received twelve such vertebræ from Bracklesham, varying in size between the two extremes given in figs. 5, 6, and 10, 11, 12, Pl. 3. The hypapophysis (*h*) which is best preserved in the vertebra fig. 10, is shorter but thicker than in fig. 1; the articular cup and ball are relatively smaller; the zygosphene (*zs*) is larger, and its surfaces larger and more vertical (fig. 5); the neural spine has a less antero-posterior extent. These may be vertebræ from the hinder part of the abdomen, near the beginning of the tail. Some of them have a minute ridge at the middle of the anterior inferior concavity (fig. 9).

A third modification of vertebra shows the same limited extent of the base of the posterior hypapophysis, but a second shorter hypapophysis is constantly developed from the middle of the space between the bases of the diapophyses. I have examined twenty of such vertebræ ranging in size between the extremes given in figs. 14, 15, and 17, Pl. 3. As compared with fig. 5, the articular cup of fig. 14 is larger, the zygosphene less, and of a different shape, concave anteriorly and not straight above, but forming an obtuse angle there. A ridge is continued from the posterior to the anterior zygapophysis (fig. 13).

This ridge is more strongly developed in the larger vertebræ with the same modification of the under surface (figs. 20, 21). The articular ball of the diapophysis would seem not to have descended so low down as in the typical vertebræ referred to *Pal. Typhæus.* The neural spine does not extend to the fore part of the zygosphene; there is a short but well-defined space above zygosphene in front of the spine.

Figs. 18, 19, 20, 21, give views of two of the best-preserved vertebræ of the present form, which I have attributed to a distinct species under the name of *Palæophis porcatus*.

The fourth modification of the Palæophidian vertebræ from Bracklesham is the most common, and is characterised by the coextension of the base of the hypapophysis with the under surface of the centrum, or by the whole of the middle of that under surface forming a ridge: both ends of the ridge being produced, the posterior one the most, and forming the normal hypapophysis. These vertebræ are usually of large size; I have examined upwards of thirty, ranging between the extremes given in figs. 25 and 26, Pl. 3; and it is from this series that I have selected the type vertebra of the genus *Palæophis*, Pl. 1, figs. 5-8.

The ridge between the anterior and posterior zygapophyes in these vertebræ is absent (Pl. 2, fig. 5) or interrupted (Pl. 3, figs. 27, 28). There is no well-defined space above the zygosphene anterior to the base of the neural spine. These vertebræ I regard as typical of the species *Palæophis Typhæus:* they are rather longer in proportion to their breadth than those of the *Palæophis porcatus*.

To this category belongs the vertebra with the unusually well-preserved neural spine (fig. 27), and likewise the two vertebræ which are preserved in their natural connexion, showing the reciprocal interlocking of their complex articular processes (fig. 28).

The fifth form of the vertebræ from Bracklesham is characterised by the compression of the centrum and the convergence of its almost flattened sides to the ridge on the inferior surface, from which a single hypapophysis is developed. I have examined not more than four such vertebræ, including the two which are anchylosed together, those (figs. 32-34, Pl. 3) being the smallest in size, and the vertebra (figs. 29-31, Pl. 3) the largest. The ridge between the anterior and posterior zygapophyses is suppressed; the neural arch gently swells out as it descends from the base of the neural spine, and from between the zygapophyses it bends in to coalesce with the converging sides of the centrum. This vertebra has not that character of a caudal vertebra, which is manifested in the *Python* and most modern *Ophidia* by the transverse pair of hypapophyses; it shows plainly the base of a single median hypapophysis from near the posterior surface of the centrum (fig. 34). The diapophyses of fig. 29 are broken away, together with the anterior concave end of the centrum; had they been entire, we might have derived from them evidence of the more constant character of the caudal vertebræ of Serpents, which is derived from the coalescence of a short and straight pleurapophysis with the diapophysis, lengthening out that transverse process, as in fig. 42. The zygosphene and zygantra are developed, as, indeed, they continue to be to near the end of the tail in modern Serpents; and the produced angle of the posterior border of the neurapophysis is as characteristic of the small compressed vertebræ of the *Palæophis* (fig. 29) as of the larger specimens.

The two anchylosed vertebræ belonging to the compressed series have been already alluded to. The base of the neural spine is limited to the posterior half of the neural arch in both (fig. 33). The hindmost of the two vertebræ is the longest, measuring

five lines, the length of the two being nine lines. In each, the sides of the centrum are nearly plane, and converge at an acute angle to a ridge, which forms the under surface; a very small hypapophysis was continued from the back end of the ridge. This process is broken away from each vertebra, as are also the diapophyses, which are indicated by their rough fractured base; they are situated near the lower part of the side of the centrum, like the long diapophyses of the posterior caudal vertebræ of the Pythons; had they been preserved, their proportions would have determined whether the anchylosed vertebræ were caudal or not.

In the skeleton of a Tiger-boa (*Python tigris*) in the museum of the Royal College of Surgeons, anchylosis of the 148th to the 149th vertebra has taken place; and the 166th and 167th vertebræ have been more completely and abnormally fused together, so as to appear like a single vertebra on the left side, and a double one on the right side, where there are two diapophyses and two ribs. The compressed form, however, and diminutive size of the two anchylosed vertebræ of *Palæophis*, strongly indicate them to be from near the end of the tail, in which case it must be concluded that that part was compressed, as in the smaller modern *Hydrophides*, and that the present extinct Ophidian was a Sea-serpent of at least twenty feet in length.

All the vertebræ with the characters specified in the description of the large specimens from the trunk, and referable to the *Palæophis Typhæus*, have been obtained from the Eocene clay at Bracklesham, Sussex: they form part of the collections of the late Frederic Dixon, Esq., F.G.S., of Worthing; of James S. Bowerbank, Esq., F.R.S.; and of George Augustus Combe, Esq., of Preston, near Arundel, to whom I have been indebted for some beautiful examples, including the two vertebræ in natural conjunction (Pl. 3, fig. 28), and the vertebra with the best preserved neural spine (Pl. 3, fig. 27.)

Palæophis porcatus, *Owen*. Plate 3, figs. 13-15, 18, 20, 21.

On comparing together eighteen Palæophidian vertebræ of different sizes from Bracklesham, the smallest of the dimensions represented in figs. 14, 15, and thence gradually increasing to the size of the specimen fig. 20, I find the following differences: in fig. 14, e. g. the articular cup and ball at the ends of the centrum are larger in proportion to the length of the centrum, as compared with the next-sized vertebra, fig. 5: the under surface of fig. 15 is convex transversely between the diapophyses and sends down a short median ridge; in fig. 6 it is concave at the same part, and without the median ridge; but both vertebræ have the median process or ‘hypapophysis’ at the back part of the under surface. In fig. 14 the fore part of the zygosphene is concave, in fig. 5 it is flat; in fig. 5 the upper border is straight, in fig. 14 it forms an open angle; the space between the zygosphene and zygapophysis is greater in fig. 5 than in fig. 14.

Twelve vertebræ of progressively increasing size repeat the characters of the vertebræ (fig. 6); i. e. they have the fore part of the under surface between the diapophyses excavated, and have only one inferior spine, viz. the hypapophysis developed from the hind part of the under surface; they have also the zygosphenal articulations nearly vertical, and raised high above those of the zygapophyses (fig. 8). A vertebra (figs. 22, 23, 24) of the same size as the largest of these twelve differs from them, and repeats the general characters of the small vertebra (fig. 14): it has the anterior as well as the posterior hypapophysis; larger terminal cup-and-ball surfaces in proportion to its size; smaller intervals between the zygosphenal and zygapophysial articulations (fig. 24); less lofty posterior aliform extensions of the neural arch, and the base of the neural spine extending nearly to the fore part of that arch. These vertebræ, and especially the larger specimens (figs. 18, 20) have a strong external ridge extending from the anterior to the posterior zygapophyses on each side of the neural arch. On comparing one of these vertebræ with another of the ordinary character and of the same size, the following further differences presented themselves: in the ridged vertebræ, which are provisionally referred for the convenience of description and comparison to a distinct species, with the name of *Palæophis porcatus,* the articular ball is broader in proportion to its height (compare fig. 23 with fig. 27); the anterior zygapophyses are more produced outwards and less produced forwards, so that they do not extend beyond the border of the articular cup, so far as in the non-ridged vertebræ of *Palæophis Typhæus;* the fore part of the zygosphene in the ridged vertebræ is broader, and less excavated. The breadth of the base of the neurapophysis is greater in the ridged vertebræ than in the unridged ones, in proportion to its length. The articular surfaces of the zygapophyses are smaller in the ridged than in the unridged vertebræ.

Figs. 13, 18, 20, 22, Pl. 3, show the ridged character of the sides of the neural arch in *Palæophis porcatus,* and fig. 19 shows the consequent superior breadth of the base of that arch in relation to the length of the vertebra as compared with fig. 8, Pl. 2, a corresponding vertebra of the *Palæophis Typhæus.* Fig. 14 in the same Plate shows the striking difference in the proportions of the same part of the vertebra in the *Python tigris.*

Such are the observed differences which seemed worthy of mention in the series of Palæophidian vertebræ from the Eocene deposits at Bracklesham which I have had the opportunity of comparing. The nature of the differences may be interpreted in different ways: with regard to the small vertebræ, for example, those with a single spine from the posterior part of the under surface (figs. 1, 2, 3, Pl. 3) may be small cervical vertebræ of the same species as that to which the large vertebræ with the two inferior spines belong; and the small vertebræ with two inferior spines (figs. 14, 15) may have belonged to a smaller and younger individual of the same species, and have come from a more posterior part of the vertebral column of such individual. The anterior vertebræ of both Pythons and Boas, for example, are distinguished by an

inferior spine, the remaining vertebræ to the tail being merely ridged beneath: but I have not met with such modifications in the trunk-vertebræ of the same existing Serpent, as those that have been pointed out in the vertebræ (figs. 5, 6, and figs. 14, 15; and in no specimen of Python or Boa, have I found the vertebræ presenting such differences of character as those indicated in the larger fossil Palæophidian vertebræ which I have described as 'ridged' and 'not ridged.' Leaving therefore the question of the nature of the differences in the smaller vertebræ (figs. 1 and 14) open, and as possibly depending upon difference of age and position in the series, I believe the characters of the ridged vertebra to be those of a distinct species of *Palæophis.*

Masses of mutilated vertebræ and ribs, irregularly cemented together by their matrix, are occasionally though rarely discovered in the Eocene clay at Bracklesham. The specimens of such aggregates which I have as yet seen have not exhibited any vertebræ sufficiently complete to yield more than the means of determining the generic relations. That of which a small portion is figured in Pl. 4, fig. 4, is the most instructive, since it shows the form and structure of the ribs. The proximal half of the pleurapophysis (*pl*) equals in size the corresponding part in the *Python regius* of twenty feet; it shows the same fine cancellous structure of the articular end, and a similar medullary cavity, with thin compact walls, forming the body of the vertebra. The more slender distal portion of another rib is preserved, with the medullary cavity exposed at its fractured parts.

PALÆOPHIS TOLIAPICUS, *Owen.* Plates 1, 4, 5.

Transactions of the Geological Society of London, vol. vi, part ii, p. 209.
Report on British Fossil Reptiles, in the Report of the British Association, 1841, p. 180.

The fossil Ophidian vertebræ which have been discovered in the London clay at Sheppy are, for the most part, smaller than those from Bracklesham; their common dimensions equalling those of a *Boa constrictor* of from ten to twelve feet in length. They all repeat, however, the generic modifications characteristic of *Palæophis;* the hinder margin of the neurapophyses (Pl. 1, fig. 4) is produced into a pointed or angular plate; the articular prominence for the rib (Pl. 5, fig. 3, *d*) is wholly convex; the zygapophyses are short, and no diapophysial point extends beyond the anterior ones; the height of the neural spine (Pl. 1, fig. 4, and Pl. 5, fig. 1, *ns*) exceeds its antero-posterior extent. The veritable Ophidian character of the Reptile to which these fossil vertebræ belonged, is not only shown by their individual structure, but is well illustrated by the number of them in natural articulation which have occasionally been found cemented together in the petrified clay.

One of these Ophidiolites from the clay of Sheppy, in Mr. Bowerbank's collection, exhibits a portion of the vertebral column of the *Palæophis* suddenly bent upon itself, including about thirty vertebræ, and indicating the usual lateral flexibility of the spine (Pl. 1, fig. 2).

As compared with either of the species of *Palæophis* from Bracklesham, the vertebræ from Sheppy have the centrum proportionally longer and more slender, with a smaller terminal cup and ball. In vertebræ from Sheppy and Bracklesham in which those articulations were of equal size, the length of the neural arch at and including the zygapophyses, was two centimetres in the *Palæophis toliapicus,* and one centimetre, seven millimetres in the *Palæophis Typhæus.*

The hypapophysial ridge is more constant and better marked; it is produced at both extremities, and most so at the hinder one, but here in a less degree than in the *Palæophis Typhæus,* or *Pal. porcatus,* and the ridge is not interrupted between the two hypapophyses, as in most of the large vertebræ of the *Palæophis porcatus.* On the other hand, the rising of the bone continued from the anterior to the posterior zygapophysis does subside midway more completely than in the *Palæophis Typhæus;* and the ridge, which in that species extends to the apex of the produced posterior border of the neurapophysis along the outside of that aliform production, is less developed in the *Palæophis toliapicus:* the neural arch is less suddenly compressed above, or inclines more gradually to the base of the spine; this spine, also, although its base is extended to near the anterior border of the zygosphene, appears to be higher in proportion to its antero-posterior extent than in the *Palæophis Typhæus.* The diapophysis is less produced outwards and downwards than in the *Palæophis Typhæus* or *Palæophis porcatus.* In a group of thirty vertebræ of this species cemented together by the indurated clay from Sheppy, in the Hunterian Collection, and which, in the original MS. Catalogue of that part of John Hunter's Collection, were called 'vertebræ of a Crocodile,' Pl. 1, fig. 1, several of the long and slender subcylindrical ribs are also preserved, in the fractured parts of which the medullary cavity is shown. The articular surface at the proximal end presents the uniform concavity suited to the convexity of the diapophysis. I have seen no evidence of the process from the upper and back part of the proximal end of the rib which is present in the Python.

The finest and most strikingly Ophidian example of the great fossil snake of Sheppy has been obtained from that locality by Mr. Bowerbank since the publication of the Memoir in which his earlier specimens of the *Palæophis toliapicus* were determined and described. It consists of a series of thirty vertebræ, from about the middle of the abdomen, bent into an oval form upon their dorsal aspect, and measuring twenty inches in length (Pl. 4, figs. 1, 2).

As the strong and complex articulations of these vertebræ in Serpents opposes any inflection of the column except from side to side, their unnatural bend in the fossil is attended with just the amount of mutual dislocation that was requisite to admit of it; but beyond this amount of dislocation, which chiefly affects the terminal ball and socket-joints, the vertebræ have been preserved in their natural juxtaposition and succession. The dead body of this primæval serpent has apparently sunk or been washed into the great stream or estuary, where it has been driven about to

and fro, and variously contorted as it was swept along by the current; the portion here preserved has been by some external influences obstructed and bent upon itself in its present unnatural curve, as it finally sank in the sediment in that state of decomposition when the ligaments were ready to give way to the strain upon them; but the tough integuments, which have longer resisted dissolution, have served to retain the partially-dislocated vertebræ together until they became fixed in the matrix in the position in which they are now fossilized. We have in this condition very good evidence of that long and slender form of body which would admit of such an extent of inflection from external pressure in a direction contrary to that which the natural articulations of the vertebræ would allow; but since in Serpents those articulations are so strong, when fresh, as to offer considerable obstacles to any vertical inflection upwards or downwards, we may infer that the body of the *Palæophis,* of which the example in question formed a part, must have floated long enough to have undergone that degree of internal decomposition, which allowed it easily to yield to external pressure in any direction.

The characteristically long and comparatively slender spine is well preserved in the vertebræ at *ns,* fig. 2; and the equally characteristic angular production of the hinder border of the neural arch is shown in some other of the vertebræ. In many vertebræ the ribs are preserved just in that degree of juxtaposition in which they would remain after yielding to the pressure and movements of the overlying and accumulating sediment upon the integument of the body. Fig. 3 shows a portion of the coil, in which a few of the ribs offer to our view the concave articular surface (*pl*), which was articulated with the diapophysial tubercle (*d*): in fractured portions of the ribs their medullary cavity is shown. The hypapophysis which terminates the thick and low inferior ridge of the vertebræ of the present species offers just that small degree of development characteristic of the middle and posterior part of the long abdominal region.

In Pl. 4, fig. 1 shows this remarkable chain of vertebræ from the right side; fig. 2 the middle portion of the same chain from the left side; and fig. 3 the under surface of the vertebræ with the juxtaposed ends of the ribs.

In Pl. 5, fig. 1 shows a group of the vertebræ of *Palæophis toliapicus,* in some of which the long and slender spine (*ns*) characteristic of the genus is well preserved. In fig. 3 of the same plate, the position and form of the diapophysial tubercle (*d, d*) are shown. The character of the under surface of the vertebræ is shown in fig. 4, and the angular aliform production of the neural arch is shown in fig. 5.

One of these characteristic examples of the *Palæophis toliapicus* is preserved in the Hunterian Museum, the others in that of James S. Bowerbank, Esq., F.R.S. In the Museum of Mr. Saull, F.G.S., a few vertebræ, and a fragment of the skull of probably the same species of *Palæophis*, likewise from Sheppy, are preserved.

On a general review of these numerous and rich accessions to our previously scanty evidence of extinct Serpents, I may sum up by stating that the generic character

of *Palæophis* is chiefly manifested in the length of the neural spine, in the pointed aliform productions of the back part of the neurapophyses, in the uniform convexity of the diapophysial tubercles, and the minor transverse production of the zygapophyses.

The *Palæophis toliapicus* is distinguished by its longer vertebræ in proportion to their breadth, by its sessile diapophyses, and by the carinate character of the lower part of the centrum in the vertebræ of the abdomen.

The *Palæophis Typhæus* is distinguished by its shorter and broader vertebræ, by its pedunculate diapophysis, and by the anterior and posterior hypapophyses of the vertebræ of the abdomen; its neural arch is narrower, and its sides not longitudinally ridged.

The *Palæophis porcatus* is characterised by the longitudinal ridges connecting the anterior with the posterior zygapophyses, by its broader and squarer neural arch; but it has the two hæmal spines below like the other large species from Bracklesham.

PALÆOPHIS (?) LONGUS, *Owen*. Plate 3, figs. 35, 36, 37, 45, 46.

Vertebræ of a serpent agreeing in character with those of the London clay at Sheppy, but smaller, have been obtained by Mr. Colchester, from the sand of the Eocene formation underlying the Red Crag at Kyson or Kingston in Suffolk. In these, as in most of the trunk vertebræ of *Palæophis Typhæus*, the hypapophysis is a small sub-compressed tubercle at the under and back part of the body of the vertebra; but there is no repetition of a smaller process at the fore part; and no ridge is continued backward from the hypapophysis, as in the *Palæophis toliapicus*. The tubercle for the rib is single; in *Naja* it is almost divided into two, the upper being convex, the lower moiety concave; in the *Python* the upper half of the tubercle is convex, and the lower half concave, but the two facets are not marked off. In the fossil serpent from Kingston, as in the *Palæophis* from Sheppy and Bracklesham, the costal tubercle is simply convex. The chief characteristic of the Ophidian vertebræ from Kingston is the length and slenderness of their bodies, in which respect they exceed those of the *Palæophis toliapicus*, and resemble some of the existing tree-snakes (*Dendrophis*) with elongated vertebræ. The origin of the neural spine is limited to the posterior half of the arch (fig. 36); but the mutilation of the neural arch in the specimens I have yet had the opportunity of examining, prevents a prosecution of the comparison with any adequate advantage.

Genus—PALERYX.

The vertebræ of this extinct genus of Serpent (Pl. 2, figs. 29-32, and figs. 37-38) differ from those of *Palæophis*, in the absence of the pointed aliform production of the hinder border of the neurapophyses, that border (fig. 29 *n*) descending from the neural

spine to the posterior zygapophyses, with a convex curve as in most modern Serpents. The neural spine (*ns*) is low, the antero-posterior extent of its truncated summit exceeding the height. There is no point of bone extending outwards beyond the articular surface of the anterior zygapophysis (*z*), as in *Coluber, Vipera, Naja, Crotalus,* and *Hydrus;* in this character *Paleryx* resembles *Eryx, Python, Boa,* and *Palæophis.* The middle and posterior trunk-vertebræ of *Paleryx* differ from those of *Python* and *Boa,* and resemble those of *Eryx* in having a sharp and well-developed hypapophysial ridge (*h*) coextensive with the under surface of the centrum, and deepest at its posterior half; but the border here is gently convex, not angular as in *Eryx;* and the posterior border of the neurapophysis is less produced than in *Eryx;* the articular cup and ball are relatively larger, especially transversely; the cup is a full transverse ellipse, not circular as in *Eryx;* in this respect it resembles that of *Python* and *Palæophis.*

PALERYX RHOMBIFER. Plate 2, figs. 29-32.

In the vertebræ of this species the hypapophysial ridge (*h*) is sharp and well produced; the neural spine (*ns*) is rhomboid, not rounded off anteriorly; the zygosphene (*zs,* fig. 30) has the same relative vertical extent as in the Python. The diapophysial tubercle (*d*) is less elongated vertically than in *Python* and *Boa,* presenting proportions like those of the vertebra of the Eryx (fig. 22, *d*); the zygapophyses (*zz'*) are more pointed at their terminations. The figures 29-32, Pl. 2 represent the largest of the trunk-vertebræ upon which has been founded the genus and species above defined: they indicate a land Serpent of about four feet in length. They were obtained from the Eocene sand at Hordwell by Alex. Pytts Falconer, Esq., of Christchurch, Hants., to whose liberality I am indebted for the specimen figured.

PALERYX DEPRESSUS, *Owen.* Plate 2, figs. 37 and 38.

The smaller Ophidian vertebræ, indicative of the above species, agree in their generic characters with the foregoing; that is to say, in the shape and development of the hinder border of the neural arch in the relations of the diapophysis to the anterior zygapophysis, in the shape and size of the articular cup and ball of the centrum, and in the shape of the diapophysial tubercle for the rib. But the whole vertebra is more depressed; the hypapophysial ridge is relatively thicker and less produced; the zygosphene has much less vertical thickness, and there is a corresponding modification of the zygantra; the neural spine is relatively lower and of a different shape, having its anterior angle rounded off, and its posterior one more produced backwards.

As I have failed to discover modifications of the kind and degree above described in the dorsal or free rib-bearing vertebræ of the same species in any of the existing genera of Serpents, I am left to interpret such characters as indicative of a distinct

species, probably of the extinct genus of Eocene Serpent above defined. The specimens of the vertebræ of the present species, which indicate a serpent of between two and three feet in length, were obtained from the Eocene sand at Hordwell Cliff, by Searles Wood, Esq., F.G.S., in whose museum they are preserved.

A few bones of serpents have been found in the superficial stalagmite, and in clefts of caves, in peat bogs, and the like localities, which bring their occurrence and deposition within the period of human history. None of these Ophidian remains, however, have offered any differences in size or other character from the corresponding parts of the skeleton of our common harmless snake (*Coluber natrix*). As yet no Ophidian fossils have been found in British fresh-water formations of the pre-adamitic or pleistocene period, from which formations the remains of the Mammoth, tichorrhine Rhinoceros, great Hippopotamus, and other extinct species of existing genera of *Mammalia* have been so abundantly obtained. Between the newest and the oldest deposits of the tertiary period in Geology, there is a great gap in England, the middle or miocene formations being very incompletely represented by some confused and dubious parts of the crag of fluviomarine origin in which teeth of a Mastodon have been found.

The deposits in which the remains of the large serpents of the genus *Palæophis* occur so abundantly, carry back the date of their existence to a period much more remote from that at which human history commences. Yet, as the strange and gigantic Reptiles that have been restored, and, as it were, called again to life, from times vastly more ancient, realise in some measure the fabulous dragons of mediæval romance; so the locality on our shore of the English channel in which the Eocene serpents have been found in most abundance and of largest size, recalls to mind, by a similar coincidence, the passage cited by an accomplished and popular historian, in his masterly sketch of the rise and progress of the English nation. "There was one province of our Island in which, as Procopius had been told, the ground was covered with serpents, and the air was such that no man could inhale it and live. To this desolate region the spirits of the departed were ferried over from the land of the Franks at midnight." (Macaulay's History of England, vol. i, p. 5.)

The discovery of Serpents of different genera and species, some, as e. g. *Paleryx*, terrestrial, and all manifesting the peculiar and characteristic vertebral organization of true *Ophidia*, at a period incalculably remote from that at which we have any evidence of the existence of man, more forcibly recalls our early ideas of the nature and origin of serpents derived from annotations to Scripture which represented them

as the progeny of a transmuted species, degraded from its originally created form as the consequence and punishment of its instrumentality in the temptation of Eve.

"The curse upon the serpent," say the learned Drs. D'Oyly and Mant, in the edition of the Bible printed under the direction of the Society for the Promotion of Christian Knowledge, ed. 1823, "consisted, 1st, in bringing down his stature, which was probably in great measure *erect* before this time ; 'upon thy belly shalt thou go,' or, 'upon thy breast,' as some versions have it: 2dly, in the meanness of his provision, 'and dust shalt thou eat,' inasmuch as creeping upon the ground, it cannot but lick up much dust together with its food."

The idea of the special degradation of the serpent to its actual form, derived from interpreting the sentence upon it as a literal statement of fact, has been so prevalent as to have affected some of the zoological treatises of the last century. Thus, in the quaint and learned 'Natural History of Serpents,' by Charles Owen, D.D., 4to, 1742, p. 12, the author, treating of the food of those reptiles, writes:—"that dust was not the original food of the serpent seems evident from the sentence passed upon the Paradisaick serpent, but the necessary consequence of the change made in the manner of its motion, i. e. the prone posture of its body, by which it is doomed to live upon food intermixed with earth."

Dr. Adam Clark, commenting more recently upon the record in its literal sense, seeks to elude the difficulties which thence arise, by contending that the Hebrew 'Nachash' may be translated 'Ape' as well as 'Serpent.' But when we find him reduced to the necessity of glossing the text by such expositions as that to go on the belly means 'on all fours;' and by affirming, of the arboreal frugivorous four-handed monkeys, that 'they are obliged to gather their food from the ground,' we have a lively instance of the straits to which the commentator is reduced who attempts to penetrate deeper than the Word warrants into the nature of that mysterious beginning of crime and punishment by the dim light of an imperfect and second-hand knowledge of the Divine Works.

If, indeed, the laws of the science of Animated Nature formed part of the preliminary studies of the theologist, the futility of such attempts to expound the third chapter of Genesis, viewed as a simple narration of facts, would be better appreciated by him ; and if he should still be prompted to append his thoughts, as so many lamps, by the side of the sacred text, he would most probably restrict himself to the attempt to elucidate its symbolical signification.

What zoology and anatomy have unfolded of the nature of serpents in regard to their present condition, amounts to this :—that their parts are as exquisitely adjusted to the form of their whole, and to their habits and sphere of life, as is the organization of any animal which, in the terms of absolute comparison, we call superior to them. It is true the serpent has no limbs, yet it can outclimb the monkey, outswim the fish, outleap the jerboa, and, suddenly loosing the close coils of its crouching spiral, it can spring into the air and seize the bird upon the wing ; thus all these creatures fall its prey.

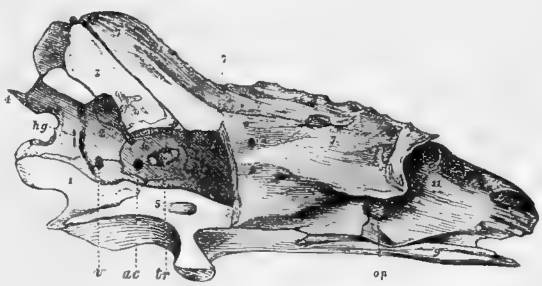
The serpent has neither hands nor talons, yet it can outwrestle the athlete, and crush the tiger in the embrace of its ponderous overlapping folds. Far from licking up its food as it glides along, the serpent lifts up its crushed prey, and presents it, grasped in the death-coil as in a hand, to the gaping slime-dropping mouth.

It is truly wonderful to see the work of hands, feet, fins, performed by a simple modification of the vertebral column—a multiplication of its joints, with mobility of its ribs. But the vertebræ are specially modified, as I have already described, to compensate, by the strength of their individual articulations, for the weakness of their manifold repetition and of the consequent elongation of the slender column.

As serpents move chiefly on the surface of the earth, their danger is greatest from pressure and blows from above; all the joints are accordingly fashioned to resist yielding, and to sustain pressure in a vertical direction; there is no natural undulation of the body upwards and downwards, it is permitted only from side to side. So closely and compactly do the ten pairs of joints between each of the two hundred or three hundred vertebræ fit together, that even in the relaxed and dead state the body cannot be twisted, except in a series of side coils.

Of this the reader may assure himself by a simple experiment on a dead and supple snake. Let him lay it straight along a level surface; seize the end of the tail, and, by a movement of rotation between the thumb and finger, endeavour to screw the snake into spiral coils; before he can produce a single turn, the whole of the long and slender body will roll over as rigidly as if the attempt had been made upon a straight stick.

Fig. 15.



Cranium of a Serpent, partially bisected.

When we call to mind the anatomical structure of the skull (fig. 15), the singular density and thickness of the bones of the cranium (1, 3, 7) strike us as a special provision against fracture and injury to the head. When we contemplate the still more remarkable manner in which these bones are applied one over another, the superoccipital (3) overlapping the exoccipital (2), and the parietal (7) overlapping the superoccipital, the natural segments being sheathed one within the other, the occipital segment (1, 3) within the parietal one (5-7), we cannot but discern a special adaptation in the structure of Serpents to their commonly prone position, and a prevision of the dangers to which they were subject from falling bodies and the tread of heavy beasts. I might enumerate many other equally beautiful instances of design and foresight—the whole organization of the Serpent is replete with such—in relation to the necessities of their apodal vermiform character; just as the snake-like eel is compensated by analogous modifications amongst fishes, and the snake-like centipede amongst insects.

But what more particularly concerns us, in the relation of the serpent to our own history, is the great and significant fact revealed by palæontology, viz. that all these ophidian peculiarities and complexities of cranial and vertebral organization, in designed subserviency to a prone posture and a gliding progress on the belly, were given by a beneficent Creator to the serpents of that early tertiary period of our planet's history; when, in the slow and progressive preparation of the earth, the species which are now our contemporaries were but just beginning to dawn; these, moreover, being species of the lowest classes of animals, called into existence long before any of the actual kinds of mammalia trod the earth, and long ages before the creation of man.

SECTION II.

THE

FOSSIL REPTILIA OF THE CRETACEOUS FORMATIONS.

CHAPTER I.—ORDER *CHELONIA.*

Genus, CHELONE, (Turtles.)

THE Cretaceous formations of England consist of the "Upper Chalk," which is white, and is commonly characterised by having horizontal layers of flint nodules; of the "Middle Chalk," which is as white as the Upper Chalk, but usually without the flints in regular layers; and of the "Lower Chalk," which when wet, and sometimes also when dry, has a gray tinge. These divisions of the chalk deposits, which in some parts of the south-east of England attain a thickness of one thousand feet, are best distinguished by some of their organic contents, as *e. g.* the *Terebratulidæ*, the *Echinidæ*, and the *Ventriculidæ.** Beneath the Chalk there is a series of Sands and Clays, which in England have received the name of "Upper Green-sand," "Gault," and "Lower Green-sand." The present Section of this History will be devoted to the description of the remains of the Fossil Reptilia that have come under the notice of the author from any of the above-named divisions of the Cretaceous Period.

One of the earliest, if not the first, indication of the occurrence of fossil Turtles in the formations of the Cretaceous Period, is given by the celebrated anatomist CAMPER, in a 'Memoir on the Petrifactions found in St. Peter's Mount, Maestricht,'† where, referring to some specimens which he had procured for the British Museum, he writes:—"Another very beautiful specimen, a foot and a half long, and about ten inches broad, I have been induced to add, because it contains the anterior part of the scutum of a very large Turtle. Of this Mr. JOHN HUNTER has an analogous bone from the same mountain in his valuable collection, but sent to him under another name. I am convinced it belonged formerly to a Turtle;—first, because I have from the same mountain the entire back of a Turtle, four feet long and sixteen inches broad, a little damaged at the sides, and a pretty large fragment of another Turtle in my possession: secondly, because I have a similar one, but so placed within the matrix, as to show the inside of that piece in the back of a large Turtle I got in London, by the favour of Mr. SHELDON: thirdly, because I have amongst these bones the lower jaw-bone of a very large Turtle, of which the crura, though not entire, are seven inches long, and distant from one another six inches; the thickness is equal to one inch and a quarter."‡ In a collection of engravings belonging to my

* See an excellent Paper, "On the different Beds of the White Chalk," by J. Toulmin Smith, Esq., in the 'Annals of Natural History' for November, 1847.

† Philosophical Transactions, 1786.

‡ Ibid., p. 450.

late father-in-law, WILLIAM CLIFT, Esq., F.R.S., there is one of a carapace of a large fossil Turtle, corresponding in size with that mentioned by Camper, and in his style of drawing. It is entitled "Tortue petrifiée trouvée dans la Montagne de St. Pierre pres de Maestricht;" and exhibits the "nuchal" and anterior "marginal" plates; ten "neural" plates, of a rhomboidal figure, carinated, and of nearly equal size, the fifth being six inches in diameter: the eight costal plates of the left side, and the first two and last three of those on the right side. The length of the first costal plate is seven inches, that of the last is little more than three inches; remains of the long and slender ribs are shown extending from the apices of the costal plates, which, in proportion to the length of the entire carapace, and to their own antero-posterior diameter, which is five inches, are extremely short, for in a carapace of a Turtle four feet in length, the costal plates must be supposed to have attained their full extent of ossification. The transverse diameter of the neural plates in this large fossil Turtle from Maestricht is three fourths that of the costal plates at the fore-part of the carapace, and is greater than that of the costal plates at the hind part,—a proportion which I have not noticed in any other Turtle, recent or fossil. The same characters appear in the figures given by M. Faujas St. Fond, of the same large species of Turtle.* CUVIER, whose superior anatomical knowledge enabled him to correct some erroneous remarks which M. Faujas St. Fond had published respecting the Chelonian remains in his 'History of the Fossils of St. Peter's Mount,' arrives at the conclusion, that they belonged to the Turtles, or marine genus *Chelone*, and to a species distinct from any existing Turtle;† but he does not notice the character of the great breadth of the neural plates, as compared with that of the costal ones; he only remarks that the great Maestricht Turtle appears to have much resembled the *Chelone caretta*.

The formation, near Maestricht, in which these Chelonian fossils occur, is the most recent member of the deposits of the Secondary epoch,—the highest and last formed of the cretaceous group: it consists of a soft yellowish stone, not very unlike chalk, and includes "siliceous masses, which are much more rare than those of the chalk, of greater bulk, and not composed of black flint, but of chert and calcedony.‡

Fossil remains of the Chelonian Order were deemed to be of rarer occurrence in the Chalk formations of England, which are apparently of older date than those at Maestricht. The first intimation of such was given by Dr. Buckland, in his 'Bridgewater Treatise' (1836), vol. ii, p. 67, pl. 44′, fig. 3*d*, which is described as a "beak of a small testudo from chalk, in the collection of Mr. Mantell, showing a fibro-cancellated bony structure, very different from the compact shelly condition of the Rhyncolite, for which it may, from its size and shape, be mistaken." Dr. Mantell states, in his 'Wonders of Geology' (1839), vol. i, p. 330, that this specimen is "from the Lewes

* Histoire Naturelle de la Montagne de Saint-Pierre de Maestricht, 4to, 800, pl. xii-xiv.

† Ossemens Fossiles, 4to ed. 1824, tom. v, pt. 2, p. 242.

‡ Fitton; Proceedings of Geol. Soc., 1830.

chalk," and probably, therefore, from the Lower Chalk. Further evidence of the remains of *Chelonia* in the cretaceous deposit is given in my paper on that subject read before the Geological Society, April 29, 1840, and published in vol. VI, p. 411, of the Second Series of the 'Geological Transactions.' The Chelonite there described and figured was obtained from the Middle Chalk at Burham, in Kent, and consisted of four marginal plates of the carapace, and a few other obscure fragments, sufficient to prove that the species was not of a *Trionyx* or *Testudo;* and as they differed in form from those of the recent species of *Chelone,* with which I compared them, and resembled rather the posterior marginal plates of some Emydians, I stated that this correspondence "rendered it probable that these remains are referable to that family of Chelonia which live in fresh water or estuaries." Subsequent observation of the various interesting modifications by which extinct *Chelones* diminish, as it were, the gap between the marine and fresh-water genera as they remain at the present day, weakened the impression which the character of the marginal plates of the chalk Chelonite first made in favour of its Emydian affinities; and the examination of the beautiful Chelonite, obtained from the same quarries at Burham, in Kent, and relieved from the chalk matrix by Mr. Bensted, described and figured by Dr. Mantell in the 'Philosophical Transactions' for 1841, demonstrated that it is not an *Emys* but a true *Chelone,* as I have stated in the note appended to my paper in the 'Geological Transactions.'

As one of the figures in Dr. Mantell's Memoir, Pl. 12, fig. 2, exhibits the extraordinary character of ten pairs of ribs in the carapace of this rare fossil, permission was obtained for original drawings to be made from the specimen, and these form the subjects of Plates 41 and 42.

From the time of Caldesi,* the constancy of the number of pairs of ribs which enter into the formation of the carapace of the Chelonian Reptiles has been confirmed by all subsequent observations. No anatomical fact, perhaps, is better determined, and more plainly and positively laid down, in all handbooks of Comparative Anatomy. Perhaps no monstrosity would sooner arrest the attention, or excite more wonder in the Comparative Anatomist, than the appearance in a recent or fossil Chelonian of a greater number of pairs of ribs in the carapace than 8. When, therefore, I saw the figure 2 of Plate XII of the volume of the 'Philosophical Transactions' for the year 1841, exhibiting not fewer than 10 expanded ribs on the left or entire side of the fossil carapace, and 9 expanded ribs on the mutilated right side of the same carapace, and found the experienced and well-known author appealing† to

* Osservazioni anatomiche intorno alle Tortarughe maritime d'Acque dolce et Terrestre; 4to, 1687.

† Dr. Mantell's words are—"The inner surface of the carapace is also thus displayed (Pl. 12, fig. 2), together with the mode of union and growth of the costal processes, and the attachment of their distal extremities to the osseous border. The accuracy of the drawings renders any detailed description unnecessary."—Phil. Trans., 1841, p. 156.

the accuracy of the drawings as an excuse for omitting any detailed description of the rare fossil, I was at first inclined to infer the existence of an extraordinary anomaly in the construction of this extinct Chelonian of the Cretaceous period; but, having more pleasure in the contemplation of the harmonies and constants of Nature than her wonders, it was with no regret that I found that the error or lusus lay with her illustrator, and not with his subject, as I have ascertained by a careful inspection of the original. The artist has supplied the additional ribs from his imagination; and in the view, in fact, in which his attention was kept more closely to the parts, as in that of the upper surface of the same carapace (Pl. XI, Phil. Trans., 1841), he gives the true number of 8 pairs of carapacial ribs or costal plates; and the author, in reference to the characters of the carapace "as shown in plate XI," states, that "it is composed of eight ribs on each side the dorsal ridge." The correct view of the under surface of the carapace is given in Plate 42, fig. 1 of the present History.

CHELONE BENSTEDI, *Owen*. Plates 41, 42, and 43.

Syn. EMYS BENSTEDI, *Mantell*. Philosophical Transactions, 1841.
CHELONE BENSTEDI, *Owen*. Report of British Fossil Reptiles, in 'Reports of the British Association,' 1841, p. 173.

The fossil in question consists of nearly the whole carapace (Pl. 41), and a considerable portion of the plastron (Pl. 42, fig. 2), with a coracoid bone (Ib., fig. 2, 52, 53).

The carapace includes all the neural plates; the usual number, viz., eight pairs of costal plates (*pl.* 1—8); and the entire border of marginal plates, save the nuchal and two or three succeeding ones (*m* 4—12, *py*). In the plastron (Pl. 42, fig. 2), the hyosternal and hyposternal bones may be distinguished. The general form of the carapace is elliptical, terminated by a point at the narrower posterior end, which, however, is less contracted than in some other *Chelones*. It is as depressed as in *Chelones* generally, as is shown in the side view, Pl. 41, fig. 2. To judge from the unmutilated and exposed neural plates, which are the first, the second, and the sixth to the tenth inclusive, the carapace appears to have been traversed by a median longitudinal crest, from which the sides gently slope with a slight convex curvature, as in *Chelone mydas*.

The more immediate indications of the close affinity of the fossil to the marine Turtles, are given by the incomplete ossification of the costal plates and of the elements of the plastron; the latter being in consequence dislocated from each other; and more especially by the shape and size of the marginal plates (Pl. 42, fig. 1, 6, 7, 8, 9) attached to the third, fourth, fifth, and sixth ribs; as also by the form and length of the coracoid bone.

The neural plates are as narrow relatively as in the ordinary *Chelones*, and differ in this respect from the broad rhomboidal plates in the *Chelone Camperi* of Maestricht. The first and second are long and narrow, with almost parallel sides; they are carinate above, and the first is crossed by the indentation of the juncture between the first and second vertebral scutes. The third and fifth are similarly indented. The eighth, which is the smallest of the neural plates, is crossed near its anterior border, by the impression of the juncture between the fourth and fifth vertebral scutes; this neural plate is 3 lines in length and 2 in breadth:* the ninth expands posteriorly into a triangular form; both these have their middle part raised into a ridge: the tenth plate is suddenly expanded, with angular sides, which slope away from a median longitudinal ridge: this is crossed by a transverse impression just anterior to its junction with the pygal or median terminal plate (*py*) of the marginal series, which is convex above and traversed by a median longitudinal furrow. The margins of this plate meet posteriorly at an open angle. The second to the seventh pairs of costal plates extend along the upper part of only the vertebral halves of the ribs, of which they appear to be expansions. The length of such expanded part of the third rib (*pl.* 3) is 9 lines; its narrow, tooth-like part, before it reaches the marginal plate, is 9 lines; about 3 lines of its extremity is inserted into the deep groove of the concave surface of the sixth marginal plate, *m*6. The width of the interspace between the narrow parts of the third and fourth ribs is 4 lines; the length of the expanded part of the first rib is $10\frac{1}{2}$ lines; the breadth of the expanded part of the first rib is 8 lines; the length of the narrow end of the rib, clear of the marginal plate, is 3 lines. In the superior breadth of the first costal plate (*pl.* 1), the *Chelone Benstedi* agrees with existing turtles, and differs strikingly from the Purbeck species (*Chelone obovata*, Pl. 9). The last short rib (*pl.* 8) sends almost directly backwards a short, narrow, tooth-like process, at right angles to the anterior margin of its sub-triangular expanded part. In *Chelone obovata* it is extended more nearly parallel with the expanded part.

The marginal plates (*m*4 to *py*) have the same general uniformity of size which we observe in the existing *Chelones* (see the Cuts 1 and 2, p. 3, of the 'Section on the Reptiles of the London Clay'); the posterior ones are not expanded as in the Purbeck *Chelone*, and in certain *Emydes*, as *Emys serrata*, &c.; but the most decisive evidence against the Emydian affinities of the present fossil is afforded by the form and development of the inferior borders of the marginal plates attached to the fourth, fifth, and sixth ribs (*m*7, *m*8, and *m*9,); for these plates, instead of being expanded and extended inwards to join the hyo- and hyposternals and to combine with these elements of the plastron in forming the lateral supporting wall of the carapace, are not so much developed in breadth as the same parts of the posterior marginal plates, but form with them an even free border, as in other *Chelones*, in which not any of the

* In all *Emydes* the proportions of this plate, when it is not suppressed, are the reverse of those in the fossil.

marginal plates are joined with the sternum. This unmistakeable evidence of the marine character of Mr. Bensted's beautiful fossil is unequivocally shown at *b*, in Pl. 12, fig. 2, of the 'Philosophical Transactions' for 1841, in which, nevertheless, the fossil is referred to the genus *Emys*.

With reference to the general imperfect ossification of the carapace, the deductions in favour of the marine nature of the Chalk chelonite might be invalidated by the hypothesis, that it was the young of some very large species of *Emys;* but the existing Emydians at the immature period when they exhibit the incomplete ossification of the carapace and plastron, have the marginal plates opposite the lateral processes of the hyosternals and hyposternals joined with those processes by an inward development of their inferior border, which is suddenly and considerably broader than the inferior border of the contiguous free marginal plates.

The outer contour of the tenth, eleventh, and twelfth plates of the *Chelone Benstedi*, projects in the form of a slight angle, and they thus differ from the same parts of *Chelone mydas* and *Chelone obovata;* most of the others have a straight free margin. The marginal plates appear as if bent upon themselves to form their outer margin, at a rather acute angle, receiving the extremities of the rib in a depression excavated in the concavity of the angle; they are nearly twice as long in the direction parallel with the margin of the carapace than transverse to it, and they are traversed in the latter direction, along the middle of their upper surface, with the groove or impression of the marginal scutes. The free edge of the upper plate of the marginal pieces is slightly notched above the insertion of the rib, and they correspond with those of the Chelonite, from the Burham chalk pit, in the collection of Sir Philip de M. Grey Egerton, Bart., F.R.S.

The form of the median or vertebral scutes of the perishable "tortoise-shell," may be traced by their somewhat wide and moderately-deep impressions. They progressively diminish in size from the second to the fifth, which is the smallest, and which covered the ninth and the major part of the eighth and tenth neural plates; but their relative breadth and the outward extension of their lateral angles correspond, like the characters of the more enduring parts, with the type of structure of the marine turtles. The breadth of the first vertebral scute is 1 inch 8 lines, that of the second scute is 2 inches, that of the fifth scute is 1 inch.

The coracoid is a bone that varies in form so as to be very characteristic of the different genera of Chelonians; it is a triangular plate in *Testudo*, a more elongated triangle in *Chelys*, a broad, bent, elongated plate in *Trionyx*, a narrower bent plate in *Emys*, a long, straight, slender bone, slightly expanded and flattened at the sternal end, in *Chelone:* now it is precisely the latter form that this bone (Pl. 42, fig. 2, 52, 53), fortunately preserved in the present specimen, here exhibits, showing that the same modifications of the skeleton, in reference to the actions of swimming, are combined in the past as in the present species of *Chelone;* it is 1 inch 7 lines in length,

cylindrical at its humeral half, and gently expanded to a breadth of 3 lines at its sternal end. The proportion which this bone presents of one fourth the length of the carapace is only paralleled in the existing *Chelones;* it is much shorter in the *Emydes.*

The hyosternal and hyposternal bones resemble rather those of the Turtles than of the young Emydes; certainly no *Emys*, with a carapace 5 inches in length, presents such forms as these bones exhibit in the present fossil; several rays or pointed spines of bone are developed from the anterior half of the median margin of the hyosternal piece, as in *Chelone caretta;* the rest of the margin continues to form the circumference of the large central aperture of the sternum. The hyposternal sends similar rays from the posterior half of its outer margin, leaving the anterior half to join, probably the same proportion of the outer margin of the hyosternal, so as to form a deep, lateral, angular notch of the sternum. The length of the hyposternal is 1 inch 2 lines. The epi-, ento-, and xiphi-sternal bones are not preserved.

From the preceding description, it must be obvious, as has been already observed, that the present Chelonite of the chalk can only be supposed to belong to the genus *Emys*, on the supposition that it is a very young specimen of some unusually large species; but against this supposition, the pointed form of the hind end of the carapace, the regularity of the size of the marginal plates, the non-development of the lower margin of any of these plates for a junction with the plastron, the long and slender coracoid, the narrow elongate form of the vertebral plates, and the broad vertebral scutes, collectively and separately militate. Whilst in all these modifications, the Turtle from the Chalk so closely corresponds with the true *Chelones*, that I cannot hesitate to refer it to the marine family of the order.

From the breadth of the xiphisternals in the remains of this species first described by me, I was induced to suppose that a new subgenus (*Cimochelys*) of marine Turtles was thereby indicated, having a closer affinity to the *Emydes* than the typical species; and the same affinity seems to be shown by the more regular elliptical form of the carapace of Mr. Bensted's beautiful specimen. The structure of the cranium, when this desirable part of the skeleton is discovered, may confirm the propriety of the sub-generic distinction; but the numerous decided marks in other parts of closer affinity to *Chelone* leave no alternative than to regard the fossil species of the chalk as a member of that genus.

It differs from all known species, especially the sub-carinated species of Sheppey (*Chelone subcarinata* and *Chelone subcristata*), in the form of the carapace, which is more truly elliptical than in any other species with which I am acquainted.

A second specimen of *Chelone Benstedi*, of the same size with that above described, also obtained from the lower chalk at Burham, in Kent, and now in the fine collection of J. S. Bowerbank, Esq., F.R.S., gives a better view of the upper surface of the carapace, but the marginal plates have been dislocated and pressed inwards beneath the narrow pointed ends of the ribs. All the neural plates are narrow and carinate

above. They are a little broader in front than behind. The slight angular production of the middle of the outer border of the posterior marginal plates is somewhat better marked than in the preceding specimen, and it gives a serrated character to that part of the circumference of the carapace which is formed by those marginal plates.

An upper view of Mr. Bowerbank's specimen is given in Pl. 43, fig. 1; a side view in fig. 2; an oblique front view, showing some of the anterior marginal plates in fig. 3; and an outline of the transverse vertical section of the Turtle in fig. 4: all of the natural size.

CHELONE PULCHRICEPS, *Owen*. Plate 48, figs. 1, 2, 3.

Report on British Fossil Reptiles, Trans. British Association, 1841, p. 172.

With the exception of a few more or less mutilated mandibles, no parts of the skull of a Chelonian reptile have been, hitherto, discovered in the chalk itself, either at Burham or elsewhere in England; but I have had the opportunity, through the kindness of the Rev. Thomas Image, M.A., of Whepstead, of examining and comparing the fossil cranium of a small turtle from the green-sand which underlies the chalk. The specimen was discovered near Barnwell, in Cambridgeshire. The general form of the skull is elongate and depressed; and it is chiefly remarkable for having the nasal bones (15) marked off by a suture from the pre-frontals (14), being a return to the typical characters of the vertebrated cranium, which I have also noticed in the skull of a larger turtle, from the Portland Stone, where, however, the course of the suture is different.

The characters of the genus *Chelone* are clearly expressed in the skull of the *Chelone pulchriceps*, by the extensive roof of bone over-arching the temporal fossæ, and by as large a proportion of this roof being formed by the post-frontals (12) as in existing *Chelones*. The orbits are also large, and their superior interspace is broad.

The median or true frontals (11) form a small proportion of the upper border of the orbits; the anterior extremities of the median frontals, instead of converging to a point, are extended forwards, between the pre-frontals, in a broader proportion than in the Portland turtle, and are obliquely truncated: it is only in the genus *Chelys* among existing Chelonians, that the pre-frontals are thus separated from each other; but in the *Chelys*, the intervening extremities of the frontals are continued to the upper border of the external nostril. In the present fossil cranium, the median extremities of the pre-frontals are arrested at the distance of four lines from the nasal aperture, which is bounded above by two distinct nasal bones (15); these bones are joined by suture to the frontals, to the pre-frontals, and to the superior maxillaries (21); the nasal processes of which extend upward, and exclude the pre-frontals from the nasal boundary. The superior maxillaries are traversed obliquely by a large and

deep scutal impression, above which the superior maxillary forms a convex prominence at the anterior part of the orbit. The groove, which traverses the frontals, is as strongly marked; that which impresses the post-frontals is fainter. The expanded trumpet-shaped portion of the tympanic bone comes nearer the upper margin of the cavity than in existing *Chelones.*

The palatal bones (20), have no palatal process anterior to the inner nostril, as in the *Chelone cuneiceps** and modern Turtles; but are situated behind that aperture, as in *Emys* and *Trionyx*, and the vomer does not penetrate between them. The palatal processes of the intermaxillary and maxillary bones form an unusually prominent angular ridge, running nearly parallel with the trenchant margin of the jaw; the bony palate is not extended along the middle line beyond the intermaxillaries, which here enter into the formation of both the inner and outer nostrils. The pterygoid bones present moderately wide and deep external emarginations.

The following are the chief dimensions of this fossil skull:

	In.	Lin.
Length of the cranium from the occipital tubercle . . .	2	4
Breadth of the cranium above the tympanic cavities . . .	1	6
Depth of the cranium at the parietal bones	1	0
Antero-posterior diameter of the orbit	0	9
Breadth of the interorbital space	0	8

The supracranial scutation of the *Chelone pulchriceps* much resembles that of the *Chelone Couanna.* A large oval syncipital scute defending the middle region of the epicranium, and being surrounded by the smaller "frontal," "superorbital," "parietal," and "occipital" scutes: the bones supporting the latter have, however, been too much mutilated to allow of their proportions and forms being determined. The fronto-nasal scutes are each bounded behind by well-defined bold curved lines, convex towards the frontal scute, and deeply indenting the frontal bones. Amongst the existing *Chelonia*, the character of the distinct nasal bones has been, hitherto, met with only in an Emydian species, on which the sub-genus *Hydromedusa*† has been founded. The modifications of the bony palate in the *Chelone pulchriceps* afford another indication of its Emydian affinities.

Chelone Camperi, *Owen.* (?) Plate 45.

Large Turtle, *Camper.* Philosophical Transactions, vol. lxxvi, 1786.

I am induced provisionally to refer to the above species the two large bony plates or scutes figured in Pl. 45, on account of their size, their shape, and especially their carinate structure. They have a smooth exterior surface, marked only by faint lines radiating from the median "carina" or ridge. They are thickest at this part, which

* History of Brit. Fos. Reptiles (Tertiary Formations), Pl. 11, fig. 3, 20. † Ib. Pl. 8, fig. 7.

is from one to two lines, and become gradually thinner to their peripheral border, which, however, is too much fractured to show whether it has been terminated by a dentated suture like the neural plates, which unite with the costal plates in the ordinary *Chelones*. The degree of thinness of the actual margins of the large scutes in question shows that they were not suturally united to costal plates. On the hypothesis, therefore, that they are the median or neural plates of a Turtle, they can only be referred, as not uniting laterally with costal plates, to the ninth and tenth of the series of neural plates, which are under the same circumstances, and which also differ from the eight preceding plates, in having contracted no osseous continuity or adhesion to the subjacent neural spines. In order to test this particular conformation I carefully excavated the chalk matrix beneath the median part of both scutes to beyond the middle of it, and exposed only a smooth concave surface: there was no trace of the median ridge, which is continuous with the summit of the spine, in the first eight neural plates of the Chelonia.

But besides the two plates, the exterior surface of which is exposed, there is a third plate, the position of which is reversed, and which has slipped under one of the scutes that has retained its natural position. A portion of a fourth similar plate is also present in a similar reversed position in the same block of Chalk. This fact, together with the thin borders of the plates, leads me to suspect that they may belong to the series of marginal plates of a large Turtle, notwithstanding the open angle at which the sides diverge from the median ridge, which, in that case, must have formed the outer and anterior border of the carapace.

On the hypothesis that these large plates have belonged to a Turtle, they indicate an individual with a carapace between forty and fifty inches long; as large, for example, as that of which CAMPER makes mention in the memoir above quoted. There is a possibility, however, that those large scutes may have belonged to some Saurian reptile, although the probability is small, on account of the absence of any rugosities, pits, or other sculptured character which marks the exteroir surface of all the dermal bony scutes of Saurians hitherto found. It is possible that the *Polyptychodon*, or the *Mosasaurus*, if their skin was so defended, might have had light and smooth scutes; but the balance of evidence is at present in favour of the Chelonian character of those in question. Their microscopic structure shows that they have not belonged to a cartilaginous fish, and it agrees pretty closely with that of the osseous tissue of unquestionably Chelonian neural plates of smaller size, from the chalk formation.

Another circumstance which also inclines me to view the large plates above described as being Chelonian, is the corresponding thinness of the costal plates where they are unattached to the subjacent ribs in the specimen from the Burham Chalk-pit, figured in Pl. 46, fig. 3. The outer surface of these plates is also smooth, or at most marked by fine striæ. The borders by which they are in contact do not show

any very distinct character of suture, but appear to have been joined by a wavy line. The length of the rib which projects beyond the conjoined costal plate is considerable, being proportionally greater than in the much smaller *Chelone Benstedi;* and the free portion of the rib is narrower, with a smoother upper surface, evidently indicating a distinction of species. The portion of carapace in question may belong to a young *Chelone Camperi.*

Of the marginal plates of that species only the anterior ones appear, as yet, to have been discovered at Maëstricht; but the liability of such slightly attached parts to be scattered and lost, renders their discovery in natural connection, as in the specimens in Pl. 45, more remarkable, perhaps, than their absence, and affords, at least, no sufficient grounds for the speculation of Faujas St. Fond, that they were cartilaginous in the large Turtle from Maëstricht. The outer surface of the bones of the carapace of the Chelonian Reptiles which actually retain the marginal plates in a gristly state, is characterised by a sculptured character, well shown in several plates of the Section on the Tertiary Chelonia, ex. Pls. 5, 6, 31, but of which no trace exists in the *Chelone Camperi,* from Maëstricht, any more than in the neural or marginal plates in Pl. 45, or the costal plates in Pl. 46 of the Chelonites from the upper chalk of Kent.

CHELONES INDETERMINATÆ.

Various portions of the fossilised skeletons of Chelonian Reptiles have been kindly submitted to me by Mrs. SMITH, of Tonbridge Wells; by J. S. Bowerbank, Esq.; and by THOMAS CHARLES, Esq., of Maidstone, from which specimens I have selected the subjects figured in Pl. 44, Pl. 46, and Pl. 48.

The specimen, fig. 8, Pl. 48, from the Collection of J. S. Bowerbank, Esq., is of a similar nature to those above described and figured in Pl. 45; but it is rather smaller, and is more decidedly shown to belong to the marginal series of scutes by the unsymmetrical development of the two sides which slope away from the median ridge; and this, also, is oblique: the sides form a less open angle: their substance, which is hardly a line in thickness at the meridian ridge, gradually thins off to the border, which is produced on one side into a number of dentated processes, that to all appearances are natural.

There are two similar but rather smaller marginal scutes in the same Collection.

Mr. John Quekett, the Assistant Conservator of the Museum of the Royal College of Surgeons, has kindly prepared sections for the microscope from the preceding specimens, and the form, size, and arrangement of the bone-cells agrees with those in similar preparations from the scutes of the recent Turtle.

The portion of mandible, Pl. 48, figs. 4 and 5, resembles that of the *Chelone planimentum,* Pl. 18, fig. 3, of a former Section, and of some of the Eocene Turtles from Bracklesham, figured in Mr. Dixon's work 'On the Tertiary and Cretaceous Deposits of Sussex,' Tab. XIII, in the great extent of the bony symphysis; but this differs in

having the upper surface traversed by two longitudinal furrows, slightly converging as they approach to the point. The outer or alveolar borders are obtusely rounded; and are perforated, as in most Chelonians, by a series of small vascular foramina: the rounded border increases in breadth as it extends backwards where it is continued upon, or forms, the outer surface of the beginning of the ramus of the jaw. The commencement of the coracoid process rises from the inner border of the ramus which is continued from the hinder and upper border of the broad symphysis. In this character, also, the present mandible differs from all that I have previously seen, either fossil or recent. In its general form it resembles, like some of those from the Bracklesham Clay, the mandible in the *Trionycidæ*, rather than that in the existing *Chelones*. The specimen is in the Collection of James S. Bowerbank, Esq., F.R.S.

In the same rich depositary of British Fossil remains is the portion of a Chelonian mandible, Pl. 48, figs. 6 and 7. It has formed part of a longer, narrower, and more pointed lower jaw than the one above described. The bony symphysis is much shorter; the rami longer, deeper, and more regularly convex on their outer side. It thus, likewise, presents the characters rather of a *Trionyx* than of a modern *Chelone;* but the modifications of the lower jaw, in indubitable species of true Turtle from the older Tertiary deposits, forbid a conclusion against its having belonged to a similarly modified species of *Chelone*.

I am indebted to Mr. Catt, of Brighton, for the specimens of the right scapula and coracoid, in almost their natural juxta-position, Pl. 48, fig. 9, of a Turtle which must have been about two feet in length, from the chalk: the letter *a* shows the surface contributed by the scapula to the humeral joint, the letter *b* that by which it was united with the coracoid: *c* is the base of the acromial process or clavicle, which has been sent off in the same oblique direction as in the recent Turtles; *d* is the beginning of the body of the slender scapula. The coracoid has been rotated, so as to show its scapular surface at *b:* that which it contributed to the shoulder-joint is shown at *a:* the long and slender shaft of the coracoid and its very gradual expansion is eminently characteristic of the marine nature of the species to which it belonged.

In Pl. 48, fig. 10, is shown the opposite side of the right coracoid of a Turtle of double the dimensions of that from which the preceding specimens came. It is from the chalk-pit at Burham, so fertile in fine fossils, and forms part of the collection of Mrs. Smith, of Tonbridge Wells. The margin of the articular end is more produced than in the *Chelone mydas*, and, as in the preceding fossil, the articular surface *b* for the scapula is relatively less in proportion to that for the humerus *a*, than in the same recent Turtle: the slender beginning of the shaft of the bone is more compressed, less triedral. I estimate the fossil fragment, by the proportions of that of the *Chelone mydas*, to have been part of a coracoid of one foot in length, and calculating the proportions of the carapace by those of the *Chelone Benstedi*, it must have been about three feet six inches in length in the Turtle from which the coracoid in question came.

Pl. 44, fig. 1 is the slender portion of the entosternal, *es*, and a fragment of the right hyosternal of a turtle, which must have been about one foot eight inches in length.

Figure 2 gives an inside view of a rib, with the connate costal plate, the gradual narrowing of which towards the free end of the rib resembles that in the *Chelone Benstedi.*

Figure 3 is a similar specimen from the carapace of a larger turtle, with the neck of the rib more freely relieved from the connate costal plate.

Figure 4 is a more mutilated example of a larger rib and costal plate.

Figure 5 is the right hyposternal of the *Chelone Benstedi,* and has belonged to a specimen not larger than either of those figured in Pls. 41—43.

Figure 6 is the humeral end of the connate scapula and clavicle of a turtle.

Figure 7 is the outer side of a marginal scute of a large turtle.

Figure 8 is the left humerus of a turtle, which differs from that of the existing species in the greater expansion of its distal end.

Figure 9 is the left ulna of a turtle, belonging to a larger example than that to which the humerus belonged.

I have been favoured with the opportunity of inspecting portions of the skeleton of a large Chelonian obtained by Mrs. Smith, of Tonbridge Wells, from the lower chalk at Burham, Kent, and skilfully relieved from their mineral bed by that lady. The principal bones consist of two series, one containing five, the other three and parts of two, of the marginal plates of the carapace, in natural connection, and from that part of the margin where they receive the extremities of the vertebral ribs (Pl. 46, figs. 1 and 2). These marginal plates in *Chelone mydas* are three-sided, and have two thick terminal borders by which they are united, suturally, to one another: of the three free surfaces, the one, directed towards the interior of the body, is concave and characterised by a deep depression for the reception of the tooth-like extremity of the rib (fig. 2); the other two (upper and under) surfaces meet at an angle, which is produced at certain parts to form the marginal dentations of the lateral and posterior parts of the carapace in that species of turtle, but is more open and obtuse in the marginal plates at the anterior part of the carapace. In the fossil the marginal plates have the general characters of those of the genus *Chelone*, but differ from those of the *Chelone mydas* in being more concave on the central or perforated side, and they are also concave at the upper side, and in a slighter degree at the under side; these sides likewise meet at a more acute angle, and this angle is produced into a sharper and more continuous ridge; but this ridge subsides at one end of the series of plates in fig. 1, and the upper and under sides gradually meet at a more open angle, which is rounded off in the first of the series. This plate, therefore, answers to the third marginal plate in the *Chelone mydas*, or that which receives the end of the first expanded vertebral rib; and the remainder, therefore, to the fourth, fifth, sixth, and seventh marginal plates: now these are precisely the marginal plates in the *Emys*

which have their inferior margins developed inwards, and articulated by suture to the lateral wall of the carapace: but these margins not being so developed or terminated in the present fossil, but, on the contrary, being inferior to the upper margin in breadth,* and terminating like that margin in a blunted edge, prove the present Chelonite to belong, like the smaller Chelonite from the same chalk-pit already described, to the marine genus *Chelone.*

The length of the carapace of the *Chelone mydas* is about nine times that of the sixth marginal plate, whence I calculate the length of the carapace to which the marginal plates here described belonged to have been about fourteen inches.

The following admeasurements will show the different proportions of the marginal plates of the present specimen as compared with the corresponding ones of a *Chelone mydas* of similar general size:—

	Fossil Chel.		*Chel. mydas.*	
	In.	Lin.	In.	Lin.
Length of the series of five plates in a straight line .	7	3	8	2
Breadth of the upper surface of the third (fifth) .	1	1	0	10
Interspace of costal depressions	1	2	1	6

Thus the marginal plates of the chalk turtle, besides being more concave, are broader in proportion to their length, or antero-posterior diameter. In these respects they correspond with the form of the marginal plates in the *Chelone Benstedi,* but more evidence must be had, before these large fossil marginal plates can be referred to a larger and older specimen of the species.

There are other two marginal plates imbedded in the same portion of chalk, with their upper, smooth, slightly concave surfaces exposed; and the toothed or sternal extremities of three of the vertebral ribs, which by their length and size also prove this specimen to be a Turtle. One of these fragments of rib measures 5½ inches, and the expanded plates developed from each side of its upper surface are concave on their exterior surface, which is flat or slightly convex in *Chelone mydas.*

A separate portion of chalk from the same pit contains the scapula and its acromial branch or anchylosed clavicle, with the articular surface which joins with the coracoid and humerus. The angle at which the scapula and clavicle meet is more open in *Chelone* than in *Emys* or *Chelys:* the present specimen presents the same angle as in the Maëstricht *Chelone* figured by Cuvier,† in which it is rather more open than in the recent species of turtle. A broad, thin, slightly concave plate of bone appears, by the radiation of the fine striæ at its under part, to represent the expanded parietal bone of the cranium.

* The upper margin, which is distinguished by a slight notch where the costal groove leads to the pit, is broader than the lower one, in these plates of the *Chelone mydas;* but the difference is less than in the present fossil species.

† Ossem. Foss., tom. v, part ii, pl. xiv, fig. 5.

Genus, PROTEMYS, *Owen*.

In the operations of quarrying a rock of the hard variety of the gray arenaceous limestone, called "Kentish Rag," which belongs to the "Green-sand" Formation, near the town of Maidstone, in Kent, Mr. Bensted, the owner of the quarry, had the good fortune to discover the dislocated remains of the carapace and plastron of a Chelonian reptile, which remains were grouped together in a slightly dislocated mass, having a circumference of three feet. This fine specimen, still unique of its kind, has been liberally transmitted, by Capt. Guise, F.G.S., its present possessor, to me for the purposes of being described and figured in the present work.

It represents, as will be shown in the account that follows, a distinct sub-genus in the Family *Emydidæ*, which may be characterised as follows:—

Sternum dilatatum, per gomphosin cum testâ conjunctum, suturis hyo-et hypo-sternorum in medio lateribusque sterni interruptis.

PROTEMYS SERRATA, *Owen*. Pl. 47.

The specimen consists of the principal part of the carapace and a small part of the plastron. The carapace presents an ovate form, being apparently widest about two thirds from the nuchal plate. Both the nuchal (Pl. 47, *ch*) and the pygal (ib., *py*) plates are preserved, and the total length of the carapace is 1 foot 1½ inch. The extreme breadth of the carapace at the part above indicated appears to have been about 9 inches. The carapace is moderately convex, but becomes concave near the margin of the hinder half, by a slight upward curve of the marginal plates there.

The nuchal plate is tranversely oblong, slightly but widely emarginate anteriorly, 3 inches 9 lines in transverse length, 1 inch 2 lines in the axis of the carapace. The first vertebral scute, *v* 1, advances within three lines of the anterior border of the nuchal plate, which bears the impressions of a small nuchal scute 10 lines wide, of the first marginal scute, and of part of the second marginal scute on each side.

The first costal plate, (*pl.* 1,) articulates anteriorly with the nuchal and first marginal plates, *m* 1, and is connate with the subjacent rib to within half an inch of its pointed end, which penetrates or abuts against the third marginal plate, *m* 3. It is impressed by the triradiate line of union of the first, *v* 1, and second, *v* 2, vertebral scutes with the first costal scute. The rib forms a strong projection on its under surface, as is shown by the impression on the left side of the carapace. The length of the first costal plate, exclusive of the free end of the rib, is 2 inches 8 lines. The first neural plate is lost. The second, *s* 2, is long and narrow, and has been, apparently,

notched posteriorly, between the two truncate angles. Its length is 1 inch 5 lines; its breadth 6 lines: there is no appearance of a carina on its upper surface. The second costal plate, *pl.* 2, is 3 inches 2 lines in length, 1 inch 4 lines in breadth; it is slightly concave in the axis of the carapace; convex in the direction of its own length or across the carapace. On the right side it is fractured, and its outer end is overlapped by the dislocated fourth marginal plate, *m* 4, into the upper border of which the free end of the rib, which now projects below it, was implanted. The upper surface of the costal plate is impressed by the triradiate line of union of the second vertebral scute, *v* 2, with the first, *c* 1, and second, *c* 2, costal scutes. The third, *pl.* 3, and fourth, *pl.* 4, costal plates have their median ends straight with the posterior angles truncate. About seven lines of the free end of the connate rib projects beyond their broad outer ends. Beyond these the carapace is broken through by the pressure of the plastron from below: the upper surfaces of the conjoined hyposternals appear at *ps*, *ps*, the dislocated parts of the carapace, which were above them, having been removed. The outer portions of the fifth and sixth costal plates are seen on the right side, terminating the one, *pl.* 5, between the seventh and eighth marginal plates, the other, *pl.* 6, between the eighth and ninth marginal plates. The seventh and eighth, *pl.* 7, *pl.* 8, costal plates are preserved on the left side. The median ends of the eighth pair seem almost or quite to have met anterior to the ninth neural plate, *s* 9, as in the *Emys levis*,* the ninth plate presents a triangular form with the apex turned forwards: the breadth of its base is 1 inch 7 lines, its length is 1 inch. The tenth neural plate is a hexagonal one, 1 inch 10 lines in length. It articulates immediately with the pygal plate, *py*, which is subquadrate, rather broader behind, where it is notched in the middle. Its length is 1 inch 5 lines; its breadth 1 inch 8 lines. Not any of these neural plates are carinate.

The left hyosternal (*ps*) has been displaced, so that its under or outer surface would be in view in the block displaying the upper surface of the carapace, Pl. 47, were not the major part of its substance retained in the other half of the block, which therefore shows in part the contour of its upper or inner surface, Pl. 48, fig. 11, from which, however, the produced outer and anterior angle is broken off, that part remaining attached to the other moiety at *ps*, Pl. 47, where it dips beneath the border of the carapace. It is this produced angle which, bending upwards and forwards, effects the union between the plastron and carapace at the fore part of the lateral wall, by its insertion into the carapace; and it affords the chief proof of the Emydian affinities of the *Chelonite* under consideration.

Yet in some respects, the hyosternal in the fossil resembles more that of a young than of an old Emydian: its median border is not straight, and the concavity of the hinder half of that border indicates a persistent vacuity in the middle of the bony plastron;

* History of Brit. Fos. Reptiles (Tertiary Formations), pl. 3, fig. 1.

the posterior border is convex, showing that it was not united in its whole extent to the corresponding anterior border of the hyposternal.

With the broad nuchal plate (*ch*) is articulated the first marginal plate *m* 1, of the right side: its upper surface is square, and is impressed by the junction of the first costal scute with the second and third marginal scutes. The second marginal plate is lost. The third is displaced, and its concave side is turned upwards: the upper and under walls of the concavity are of almost equal extent, and meet externally at a right angle. Unless the back part of this plate has been turned forwards, it differs from the corresponding plate in the Emydians in not having the inner concavity confined to the posterior part, but extending its whole length, as in Thalassians; its proportions, however, are such as we find in the genus *Emys.* The fourth marginal plate, *m* 4, has its inferior and superior walls equally produced, as in Emydians, and meeting at a right angle: it articulates with the second costal plate, and probably, also, with the hyosternal below, but it has been displaced upwards. The fifth marginal plate is lost. Only the outer margin of the sixth, *m* 6, is produced; this also shows an upper and an under plate meeting at a right angle. The seventh marginal plate, *m* 7, which is preserved on the left side, although fractured, shows its rapid progressive compression towards its posterior border. The eighth marginal plate, *m* 8, is a broad, subquadrate, depressed plate, with a thin outer margin, and the thicker inner margin slightly produced into the angle between the fifth and sixth costal plates: its upper surface is concave, and impressed with the T-shaped union of the third costal scute with the eighth and ninth marginal scutes. The ninth marginal plate, *m* 9, presents a similar form; its outer border is injured. In the tenth marginal plate, *m* 10, the impression of that border is left on the matrix, showing that it had an angular notch. The same character is as strongly marked in the eleventh marginal plate, *m* 11, and the pygal plate, as has been already observed is notched at the middle of the posterior border. It is from the consequent serrated character of the hinder border of the carapace that the specific name has been taken.

Compared with the existing species of the genus *Chelone*, the present fossil differs greatly in the completeness of the ossification of the carapace, due to the extension of the costal to the marginal plates: in the form and proportions of the marginal plates, especially from the first to the seventh inclusive; and in the form of the recognisable elements of the plastron, more particularly in the curved and produced angle of the hyosternal. But when we compare it with some of the extinct Turtles of the Eocene epoch, as *e. g.*, *Chelone longiceps*, *Chelone convexa*, and *Chelone subcarinata*, the difference in regard to the extent of ossification of the costal plates is less; whilst the persistent partial want of union between the elements of the plastron in the present fossil, approximates that part of its skeleton to the condition of the plastron in the Eocene *Chelones* above cited, in which the ossification of the plastral elements has proceeded further than in the typical Turtles.

In these extinct species, the life-periods of which successively stretch backwards in time from the oldest Tertiary to the newer Secondary Epochs, there is plain evidence of a gradual breaking down of the distinctions that now trenchantly divide the fresh-water from the marine species: the actual interval being then filled up by several well-marked species, that have apparently perished.

The Thalassian affinities of the Emydoid *Chelones* of the Eocene Period were, nevertheless, in some instances well established by the structure of the shell, and by the forms and proportions of the limbs,—parts, which it is important to bear in mind, are more constant in their nature than the dermal ossifications on which the solidity or otherwise of the carapace and plastron depends. And it must also be remembered, that with the transitional species, there were associated good typical forms of Turtle, *e. g.*, *Chelone planimentum* and *Chelone crassicostata,* as well as of Fresh-water Tortoises; *e.g.*, *Emys levis, Emys bicarinata, Platemys Bullockii.*

The *Chelonite* from the Maidstone Green-sand, which forms the subject of the present section, deviates from the typical Emydian structure in the arrest of the dermal ossification requisite for the complete solidification of the plastron, and, perhaps, also in the form of the third pair of marginal plates; but, with the exception of this doubtful point, the structure and form of every other element of the carapace are more strictly Emydian, than in the most modified of the Eocene *Chelones* above cited; and the Emydian affinity is more decisively shown in the form of the hyosternal element, Pls. 47 and 48, fig. 1, *hy*. The departure of which from that of a mature typical *Emys* does not bring it so near to the form of the same element in the typical *Chelone,* as it does to that of an immature *Emys,* Pl. 48, fig. 12. In the nature and amount of departure from the Emydian type recognisable in the *Protemys serrata,* there is plainly to be seen an arrest of the development of the plastron, which so far as it has proceeded, has followed that type: there is no trace of a deviation from the embryonal common fundamental pattern of the part towards the special modifications characteristic of the genus *Chelone.*

In the small Turtle from the Chalk (*Chelone Benstedi*) the ossification has extended from the hyosternal and hyposternal centres by many diverging rays; the inferior plates of the marginal bones, Pl. 42, fig. 1, 4—12, are feebly and subequally developed throughout; and there are other differences from the *Protemys serrata* of the Green-sand, which no degree of immaturity in the Chalk specimens exhibiting them would explain, as, *e.g.*, the carinated neural plates, Pls. 41 and 43, *s, s*, and the pointed pygal plate, Pl. 41, fig. 1, *py*.

Were a recent form of *Emydian,* so modified as the large species from the Maidstone Green-sand, to be presented to the study of the modern Erpetologist, one cannot doubt, but that it would be referred to a distinct sub-genus in the Fresh-water family; and I have accordingly characterised such, as far as the condition of the *Chelonite* in question will permit. It is to be hoped, that future discoveries may bring

to light the modifications of the head and limbs of the *Protemys:* from those of the plastron we may infer that the species was more aquatic in its habits than the typical Emydians. The *Protemys serrata* may have been an Estuary species, and its discovery in the same formation and quarry as that in which the remains of an Iguanodon have been found, adds probability to the explanation of the occurrence of the latter in a Green-sand or Neocomian Deposit, on the supposition that the carcase had been drifted out to sea.

CHAPTER II.

ORDER, *LACERTILIA.*

LIZARDS.

In passing from the Tertiary to the Secondary periods of Geology, in quest of the evidences of Reptilian organisation, we have found no material change in that of the Chelonian order; the characters by which the marine species are now generically separated from other *Testudines* of Linnæus, and which were not deemed worthy of that distinction by the great systematic reformer of Natural History, are recognisably retained in the old Turtles, the contemporaries of the Ichthyosaurs, Plesiosaurs, Pterodactyles, and Belemnites, that swam the ocean in which the Corals and Sponges lived, which deposited the main part of the material that now constitutes our Chalk Downs. The differences which are traceable on a comparison of the Turtles of that period with those of the Tertiary deposits and of the actual seas, merely prove them to have been distinct species, with some slight indications of a nearer affinity to the Emydian type of structure than we observe in the present representatives of the genus *Chelone.*

The Lizards of the present day are characterised, with the exception of one genus, *Gecko,* by the same cup-and-ball articulation of the vertebræ as the modern Crocodiles, viz. with the cup at the fore part of the body of the vertebra and the ball at the back part, an arrangement signified by the term "procœlian," as applied to such vertebræ. The fossil Lizards of the Cretaceous period, whether terrestrial, amphibious, or more especially modified for marine life, present the same procœlian type.

Tribe, REPENTIA.

Genus, RAPHIOSAURUS, *Owen.*

'Transactions of the Geological Society,' vol. vi, 2d Series, p. 413, April, 1840.

Species, *Raphiosaurus subulidens,* Owen, (Plate 9, figs. 1, 2, 3.)

Report on British Fossil Reptiles, 'Trans. of British Association,' 1841, pp. 145, 190.

In a Memoir communicated to the Geological Society of London in 1840, and in

my 'Report on British Fossil Reptiles,' published in the volume of 'Reports of the British Association' for 1841, p. 145, I proposed the name of *Raphiosaurus** for a genus of small extinct lacertine *Sauria*, characterised by slender awl-shaped teeth, attached by anchylosis in a single series to the bottom of a shallow alveolar groove, and to the inner side of an outer wall or parapet of the same groove; thus corresponding with that type of saurian dentition called 'pleurodont' amongst modern Lizards.†

The specimen figured in Pl. 9, figs. 1, 2, 3, on which that genus was founded, was discovered in the Lower Chalk near Cambridge, and forms part of the rich collection illustrative of the Cretaceous Formations of Cambridgeshire, in the possession of James Carter, Esq., M.R.C.S., to whose kindness I am indebted for the opportunity of describing the specimen. It consists of a considerable portion of the dentary part of the lower jaw, and contains twenty-two of the above-described teeth, arranged in a close series: in fig. 2 some teeth are shown in place; in fig. 3, *a* and *b* show teeth with the crown broken off; and *c* is the groove or incomplete socket of a shed tooth.

At the period when this fossil was described,‡ the only vertebræ of a lacertine Saurian, which at all approximated to the proportions of the species indicated by the jaw and teeth of the *Raphiosaurus*, were those which Sir Philip de M. Grey Egerton, Bart., had kindly submitted to my inspection, and which are figured in the volume of the 'Geological Society's Transactions' already cited.§ That chain of vertebræ was discovered in the lower chalk of Kent, at Burham pit, and manifested specific distinctions from the vertebræ of the existing genera of Lacertians, with which I was able to compare them in 1840; and at that time I could only suggest, when pressed for a closer determination, that, on the hypothesis of their having belonged to the same species as the fossil Lacertian from the Cambridge Chalk, they must be referred to a Lizard generically distinct from any known existing species. Other specimens with which my lamented friend Mr. Dixon subsequently supplied me, have rendered it highly probable that the vertebræ (figured in Pl. 9, fig. 4) belonged to an extinct Lizard, distinct from the Cambridge *Raphiosaurus*, with the vertebral characters of which species we are still, therefore, unacquainted.

I have been favoured, by W. H. Bristow, Esq., with the inspection of portions, about one inch and a half in length, of the upper and lower jaws of a Lizard; the rami of the lower jaw being a third of an inch in depth, with long, slender, awl-shaped teeth, answering to those of the *Raphiosaurus*. There were five of these teeth fully formed in the portion of the upper jaw, with intervening small ones in the course of development. The portion of lower jaw had three or four irregular rows of small apertures opening on its outer side. These specimens were found in the chalk at Northfleet.

* From ῥαφίον, an awl; σαῦρος, a lizard. † Odontography, 4to, p. 182.

‡ Transactions of the Geological Society, 2d Series, vol. vi, p. 412, 1841.

§ Ib. p. 413, pl. 39, fig. 3.

Genus, CONIOSAURUS,* *Owen.*

Species, *Coniosaurus crassidens.* (Pl. 2, figs. 18, 19, 19 *a*, and 20.)

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 386.

Two genera of Lizards of the Cretaceous period, with procœlian cup-and-ball vertebræ, similar in size and form to those of the series figured and described in the 'Geological Transactions,' vol. vi, 2d ser., pl. 39, fig. 3, are now no longer hypothetical, but have been satisfactorily established by the discovery of portions of jaws and teeth associated with such vertebræ. The first of these specimens, which discloses a small extinct Lacertian, distinct from *Raphiosaurus*, and characteristic of the chalk formation, was obtained from the Middle Chalk at Clayton, Sussex, and forms part of the choice and instructive collection of HENRY CATT, Esq., of Brighton. It is figured in 'Lacertians,' Pl. 2, figs. 19 and 20, and a group of vertebræ of apparently the same species is represented in fig. 19.

These vertebræ are represented of the natural size. Like those first figured in the 'Geological Transactions,' tom. cit., pl. 39, they present an anterior concavity or cup, and a posterior ball upon the bodies for their reciprocal articulation; and a tubercle is developed from each side of the vertebral body near its anterior end, for the articulation of the rib. The non-articular surface of the vertebra is smooth; its under part is concave in the axis of the body, convex transversely. On the very probable supposition, however, that the vertebra, *v*, fig. 19, belonged to the same animal as the jaw which is imbedded in the same portion of chalk, such vertebræ must be smaller in proportion to the head than in the extinct species of Lacertine Saurian, Pl. 8, fig. 1, likewise from the chalk, and to which there will be adduced reasons for believing that the fine specimen, in the collection of Sir P. de M. Grey Egerton, Bart. (Pl. 9, fig. 4), belongs. The fossil jaw and teeth in Pl. 2, fig. 19, determine the distinctness of the *Coniosaurus* from the above-named fossil, as well as from all known recent Lizards.

The dentary bone contains from eighteen to twenty teeth; the anterior five or six teeth are slender, slightly recurved, pointed, or laniariform; the rest progressively increase in thickness as they are placed further back; expanding above the neck, slightly compressed laterally, most convex inwardly, with an anterior border, which is more prominent and curved than the posterior one: the anterior margin is further characterised by a longitudinal groove on its outer side. Some of the posterior teeth show a slight longitudinal indent near the posterior obtuse border; the last molar is smaller and more obtuse than the others. The enamel is very finely wrinkled. The teeth are closely and rather obliquely arranged; the long simple roots are anchylosed to the bottom of the shallow alveolar groove, and to the inner side of the outer wall,

* Κονις, ιος, chalk; σαύρος, lizard.

and their excavations indicate the usual mode of succession and displacement: a few alternate teeth have been shed.

The mode of attachment more resembles that which characterises the teeth in *Lacerta* proper and other "cœlodont" genera of the Lacertian tribe; but in the number, proportions, and general shape of the teeth, the present species more resembles some of the Iguanian tribe. The anterior coronal groove is continued to the anterior margin of the crown, which it slightly indents in the larger teeth; but this is the only approach to that complex structure which characterises the teeth of the typical *Iguanidæ*. Pl. 2, fig. 19 *a* is a magnified view of the crown of one of the anterior teeth; and fig. 19 *a'* of one of the posterior teeth.

There is no existing species of the Iguanian or other herbivorous family, nor of any of the 'pleurodont' Saurians, with which the present chalk-fossil is identical; nor can I refer it to any of the established genera of *Lacertilia*. The absence of the cranium and bones of the extremities, does not allow of any closer comparison with the Monitors, Iguanas, or Scinks; but the characters of the teeth justify the consideration of the fossil as the type of a hitherto undescribed genus and species, which I therefore propose to call *Coniosaurus crassidens*, or the thick-toothed Lizard of the Chalk formation.

The specimens represented in figs. 18, 19, and 20, are from the Clayton chalk-pit near Brighton: a smaller portion of a lower jaw and a few teeth have been obtained by Mr. Dixon from the Washington chalk-pit near Worthing: and vertebræ have been found by Mr. Catt in the upper chalk near Falmer, during the cutting of the railroad from Brighton to Lewes. These are the only specimens of the genus and species that have yet been discovered.

Genus, Dolichosaurus,* *Owen.*

Dixon's 'Geology of Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 388.

Species, *Dolichosaurus longicollis*. (Plate 8, figs. 1 and 2.)

My esteemed friend the late Frederic Dixon, Esq., F.G.S., in the course of his indefatigable inquiries respecting the fossils of the cretaceous period, obtained such information relative to the unique specimen of the mutilated head and anterior thirty six vertebræ of the fossil Lizard from the lower chalk of Kent, in the admirable collection of Mrs. Smith of Tunbridge Wells, figured in Pl. 8, fig. 1, as left no doubt in his mind that it formed part of the same skeleton with the chain of posterior abdominal and sacral vertebræ in the collection of Sir P. de M. Grey Egerton, Bart., M.P., F.G.S., and which is figured in the 'Geological Transactions,' 2d Series, vol. vi, pl. 39; and in the present work at Pl. 9, fig. 4.

* Δολῖχος, long, σαυρος, lizard.

Both specimens are from the same quarry or pit at Burham, in Kent, were found at the same time, and there is good reason to suppose in the same block of chalk. It appears, however, that they were disposed of by the quarrymen to different persons, and ultimately found their way to the two collections of which they are now respectively the ornaments.

Assuming, then, the two groups of vertebræ to have belonged to the same skeleton, and the conformity in shape and size of the vertebræ and ribs favours the conclusion which Mr. Dixon had drawn from the historical evidence, we may then enumerate fifty-seven vertebræ between the skull and the pelvis, supposing that none have been lost between the end of the specimen in Pl. 8, fig. 1, and the beginning of that in Pl. 9, fig. 4. Amongst existing Lizards this number of trunk (cervical, dorsal, and lumbar) vertebræ is equalled only by those snake-like species (*Pseudopus, Bipes, Ophisaurus*) which seem to make the transition from the Lacertian to the Ophidian reptiles: but not any of such genera manifest so well-developed a humerus and scapular arch as are indicated in Pl. 8, fig. 1, or so complete a sacrum and pelvic bones as are shown in Pl. 9, fig. 4. Of those existing Lacertians which had the hinder extremities as well developed as in the extinct species under consideration, the greatest recorded number of vertebræ between the skull and the sacrum is forty-one.*

Although the evidence relating to the discovery of the specimens (Pl. 9, fig. 4, and Pl. 8, fig. 1) is such as to lead me to deem it highly probable that they form the anterior and posterior moieties of the backbone of the same individual; yet, as it does not amount to absolute demonstration, the characters of the Saurian in question must for the present be rigorously deduced from those parts which are unaffected by such uncertainty. In this fit condition for scientific comparison must be regarded the fragment of skull, and the chain of thirty-six vertebræ imbedded in one block of chalk, and represented in Pl. 8, fig. 1. The most cautious and sceptical Palæontologist must admit, after scrupulous examination of the specimen, that the jaws and the portion of vertebral column, which are accurately figured in the plate, have belonged to one and the same animal, having been subject to no greater amount of dislocation than is represented at the twenty-fifth vertebra for example, and in the position of some of the ribs. Viewing the slight extent of displacement of any of these parts in the fossil, it is very improbable that the scapular arch should have been subjected to any considerably greater degree of displacement; and taking, also, into consideration the gradual diminution of the vertebræ, as they extend forwards from the place of the scapular arch in the fossil, at the eighteenth or twentieth vertebræ, to the cranium, and the remarkable and striking difference in the shape and size of the pleurapophyses (vertebral ribs, *pl.*, *pl.*) in those anterior vertebræ, I am led to conclude that the position of the remains of the scapular arch in the fossil was, in relation to the vertebral

* According to the table in Cuvier, Leçons d'Anat. Comp. i (1836), p. 221, *e. g.* in the *Scincus ocellatus.*

column, its true position in the skeleton of the living reptile, and that the vertebræ anterior to it answer to those which are called cervical by Cuvier, in the existing lizards which have four well-developed extremities.

The artificial character of the 'cervical' vertebræ of anatomy is more obvious in the Lacertine Sauria than in most other vertebrates. Cuvier, who has assigned the precise number of such vertebræ to several species of Lacertians, in his 'Table of the Vertebræ of Reptiles,'* does not define their characters. He merely observes that "they have inferior crests like the anterior dorsal vertebræ."†

With regard to the Monitor (*Varanus*) Cuvier affirms, in another work,‡ that the "inferior crest distinguishes the cervical from the dorsal vertebræ;" but he admits that the first three of these dorsal vertebræ have an inferior tubercle. Proceeding next to speak of the American Monitor (*Monitor* proper, or *Tejus*) he says,—"Les vertèbres cervicales, déterminées par les fausses côtes antérieures, sont au nombre de huit, c'est-à-dire qu'il y a six paires de ces fausses côtes."§ This number of so-defined cervicals is found in the Iguanians, Basiliscs, true Lizards, Geckos, Anolises, Agamians and Stellios. But Cuvier admits that two if not three of the last of these cervical vertebræ, although their false ribs (pleurapophyses) do not reach the sternum, are embraced by the scapular arch, and concur in the formation of the chest: if these be accordingly subtracted, the number of cervicals will be reduced, Cuvier says, to five. In the 'Table of Vertebræ' above cited, only four cervicals are allowed to the Iguana, Basilisc, the banded Gecko, Anolis, Agama, and the Levantine Stellio. There is a difference, however, in the number assigned to some of these species in the table in the 'Ossemens Fossiles.'‖ But all these discrepances depend on the inconsistent characters that hitherto have been assigned to the cervical vertebræ of Lizards.

Recognising the artificial nature of such a group of vertebræ, I believe that their character, which must needs be arbitrary, would be most easily determined, and, therefore, most convenient in its application, which should be founded on the absence of sternal ribs (hæmapophyses): according to which character the vertebra that first was joined to the sternum by sternal ribs would be reckoned as the first "dorsal," and all anterior to it as "cervical vertebræ." This arbitrary character would agree with that by which the cervical vertebræ are, in point of fact, defined in the human subject and mammalia generally.

In the fossil Lacertian, however, which forms the more immediate subject of this description, there is no indication of a junction of the vertebral rib (pleurapophysis) by a sternal rib (hæmapophysis) with a sternum (hæmal spine), and I can only compare the cervical region of the spine with that in existing Lacertians, in so far as relates to

* Leçons d'Anat. Comp. i, (1835,) p. 220.

† Ib. p. 215.

‡ Ossemens Fossiles, 4to, v, pt. ii, p. 284.

§ Ib. p. 285.

‖ Tom. cit. p. 288.

the vertebræ situated between the skull and the scapular arch. The number of vertebræ so situated in modern Lacertians is usually five, and rarely exceeds six: in the *Dolichosaurus* it was seventeen. In modern Lacertians the bodies and neural arches of such cervicals are scarcely inferior in breadth to the succeeding vertebræ, and commonly surpass them in depth by reason of the largely developed inferior spinous processes. The short anterior pleurapophyses are usually thick, broad, and expanded at their extremities, or are "hatchet-shaped" (*Cyclodus, Tiliqua, Scincus*). Besides the superior number of the cervical vertebræ in the *Dolichosaurus*, they exhibit a more decided decrease of size as they approach the head: the pleurapophysis of the third or fourth vertebra is short, almost straight, and very slender: that of the eighth or ninth vertebra is also very slender, and but a little longer: those of the three succeeding vertebræ progressively, though slightly, increase in length, but the vertebral ribs do not exhibit their normal length until the seventeenth or eighteenth vertebra: the pleurapophysial character of these eighteen or twenty anterior vertebræ is much more like that of the same vertebræ in the Ophidian than in the existing Lacertian reptiles: and there is no trace of any of the vertebral ribs having supported sternal ribs, or having been attached by these to a sternum. The slender anterior ribs increase in length, however, more gradually in the *Dolichosaurus* than in Serpents.

The occipital region of the fossil skull, with the atlas and dentata, have been too much crushed to allow of their structure being accurately determined and compared: the first tolerably entire vertebra appears to be the fourth from the head: the expanded back part of the neural arch receives the contracted fore part of that arch of the fifth vertebra: the base of the neural spine is slightly expanded posteriorly. In the fifth and succeeding vertebræ, the anterior articular processes look upwards, the posterior ones downwards, and they are simple as in ordinary Lizards, but rather longer and more slender. The thin base of the neural spine extends along the middle of the summit of the entire arch; the sides of which slope downwards and outwards more gradually, i. e. do not curve outwards so suddenly as in the *Iguana* and *Cyclodus*. The short convex diapophysis (*d*) supporting the rib is developed from the side of the fore part of the centrum beneath and a little behind the anterior zygapophysis. I excavated the chalk beneath the seventh vertebra, and exposed a short compressed 'hypapophysis,' or inferior spine projecting downwards from the middle of the hinder half of the centrum. The ribs are hollow, as in the *Cyclodus** and in Ophidians. The long pleurapophyses of the twentieth and succeeding vertebræ are more compressed than in the *Iguana* and *Cyclodus*: they are less regularly or gradually curved; the comparatively straight middle portion after the first slight bend is too constant in the ribs of the fossil not to be natural: this shape of the ribs indicates the abdomen to have been

* The vertebral ribs (pleurapophyses) are probably hollow in other Lacertians, but I cite only the genus in which I have found them so in the present comparison.

more compressed, as the number of vertebræ shows it to have been longer than in the *Iguana* or *Cyclodus*. The twenty-sixth vertebra is dislocated: the two following are turned upon their side and expose the under part: here the inferior spine has disappeared: the surface is smooth, slightly punctate, gently concave lengthwise, convex transversely. Figure 2, Pl. 8, gives a direct side view of the best-preserved ramus (the left) of the jaw: below, in outline, of the natural size; above, magnified. The extent and upward curve of the coronoid piece most resembles that in the *Varanus* (Cuvier, loc. cit. pl. 16, fig. 8 *c*); but in this genus it is relatively shorter than in the *Dolichosaurus*, and in other recent Lacertians it is still shorter and more pyramidal in shape. The extent of the surangular, and its length behind the coronoid, are Lacertian characters: but the outer surface is divided by a longitudinal ridge or angle into an upper and a lower facet, the upper one being slightly excavated: the enamelled crowns of the last four teeth show a simple obtuse shape; they are chiefly remarkable for their small proportional size. The two dentary bones meet at an acute angle; that on the right side joins a surangular piece which is continued back to near the articular surface. Allowing a symphysis of the ordinary lacertian proportions, the length of the under jaw may be estimated to have been four centimeters (one inch seven lines), or equal to between four and five dorsal vertebræ. One of the vertical columelliform bones is preserved on the left side of the cranium.

Parallel with the eighteenth, nineteenth, and twentieth vertebræ lie the remains of a broad, thin, and flat bone, with a smooth emargination, and a rough or slightly granulated surface. As the broad, thin, and anteriorly emarginate scapula of the Iguana presents a similar surface, I conclude this part in the fossil to be scapula; and the short, thick, subcylindrical, hollow bone, behind it, which is slightly twisted and expanded at both ends, to be the shaft of the humerus: it is shorter in proportion to its breadth than in the existing Lizards, and probably supported a shorter fore-arm and fore-foot; the whole limb being therefore perhaps more formed for swimming than in the Monitors and Iguanæ.

The ball-and-socket structure of the vertebræ is better adapted to sustain the body on dry land than the biconcave structure; but the modern Crocodiles, the Amblyrhynchus or marine lizard of the Gallopagos Islands, the Salamander, and even the Lepidosteus amongst fishes, prove it not to be incompatible with aquatic habits. The *Dolichosaurus*, with a procœlian type of vertebrate structure, and amongst the earliest reptiles that manifested such structure, may well have been a good swimmer and frequenter of the ancient ocean of its epoch, as well as a crawler on dry land. Although the articulations of the vertebræ must have limited if not prohibited rotation or inflection of the spine in the vertical direction, the extent of lateral flexuosity is considerable; the double curve of the fore part of the vertebral column, preserved in Pl. 8, fig. 1, being, if not the natural one assumed in the last struggles of the dying

animal, that which the vertebral joint freely allowed in the dead carcase before it became fixed in the chalk-mud.

Assuming that the specimens Pl. 8, fig. 1 and Pl. 9, fig. 4, give the natural length of the neck and trunk of the *Dolichosaurus,* to which trunk the size of the anterior caudal vertebræ indicate a long and strong tail to have been appended, the progress of the long and slender *Dolichosaurus* through the water would be by flexuous and undulatory lateral movements of the entire body, like those of a water-snake or eel.

The specimen Pl. 8, fig. 1, demonstrates that this procœlian Lizard of the cretaceous period had a smaller head, and a longer, more slender, and tapering neck, than any known existing species of the Lacertian order of Reptiles.

The hinder moiety of the trunk-vertebræ, with part of the pelvis and root of the tail, Pl. 9, fig. 4,—which, from the correspondence of size, shape and structure of the vertebræ, I refer to the *Dolichosaurus,* and from the evidence above given, corroborated by the disposition of the parts in the chalk-matrix, I believe to be part of the same skeleton as the anterior moiety, Pl. 8, fig. 1,—includes twenty-one abdominal, two sacral, and five caudal vertebræ. They have been exposed by the removal of the chalk from their inferior or ventral surfaces, the operation having been commenced from the opposite side of the block from that at which the exposure of the part of the skeleton in the other portion of the same block of chalk has been effected. The bodies of the vertebræ and the ribs show the same disposition and slight degree of dislocation as in the specimen. The ribs have been pressed by the weight of the surrounding chalk, as the soft parts yielded and became decomposed, close to the sides of the vertebræ, but with scarcely any further dislocation; and the vertebræ, maintaining the close articulations of their cup-and-ball surfaces, continue, with not more deviation from the straight line than a slight flexuosity, like that shown by the last six vertebræ in the moiety of the skeleton in Pl. 8, fig. 1.

The under surfaces of the vertebræ exhibit the same smooth, imperforate, longitudinally concave, transversely convex surfaces, as in the anterior dorsals of the last-described specimen: as in that specimen, also, they are longer in proportion to their breadth than in the Monitor (*Varanus ?*) figured by Cuvier,* or than in the *Iguana, Cyclodus* and *Tiliqua :* the diapophyses rise by a shorter base than in the *Iguana:* in an Australian *Tiliqua* I find the under surface of the centrum with two vascular perforations towards its fore part, which are not present in the *Dolichosaurus,* nor in many of the existing Lacertians. Each diapophysis forms a short rounded tubercle, immediately below the base of the anterior zygapophysis; and the simple, slightly expanded head of the rib is excavated to fit the tubercle. In the degree of compression and expansion of the proximal portions of the ribs, and in their curvature, the present precisely corresponds with the preceding portion of the skeleton of the *Dolichosaurus;* and it is

* Ossem. Foss., v, pt. ii, pl. 17, fig. 23.

obvious that the natural form of the abdomen must have been deep and narrow, like that of the Water-Snakes (*Hydrophides*).

The length of the last two abdominal vertebræ slightly decreases: a short, slender, nearly straight and pointed pleurapophysis projects outwards from the diapophysis of the last abdominal (lumbar) vertebra with which it has become anchylosed. The pleurapophyses of the next two vertebræ are equally confluent with the diapophyses, but are rather longer and much thicker than those of the preceding vertebra: they are also slightly expanded and truncate at their ends; they determine by these proportions the 'sacral vertebræ,' which thus agree in number, as in general structure, in the *Dolichosaurus* with those in existing Lacertians.

Part of the bodies of the two sacral vertebræ has been destroyed, but evident traces of the persistent cup-and-ball articulation between them remain. In the Scincoids the bodies of the sacral vertebræ become anchylosed together. The extremities of the sacral pleurapophyses come into contact in the *Dolichosaurus*, but do not coalesce: the second sacral vertebra presents a ball to the first caudal, as in existing Lacertians, not a cup, as in the modern *Crocodilia*. On the right side of the specimen the hinder half of the iliac bone extends backwards, projecting freely a short way behind the second sacral pleurapophysis, as in some modern Lacertians (*Cyclodus*, e. g.). On the left side a part of the ilium is preserved, which extends to the acetabulum. A portion of the expanded ischium is likewise preserved, and the distal half of the left femur extends back in a right line from the position of the hip-joint. The length of the entire femur could not have exceeded three centimeters, or fourteen lines; it thus agrees in its relative shortness with the humerus in fig. 1, 53, and accords with the idea that the *Dolichosaurus* was more aquatic in its habits than the modern Lacertians, most of which have longer proportional humeri and femora. The femur of the *Dolichosaurus* had a medullary cavity. The under surface of the first two caudal vertebræ is impressed by a median, longitudinal, shallow canal, bounded by two slight ridges, diverging posteriorly in the second caudal to the tubercles (hypapophyses) that have supported the hæmal arch; these tubercles are close to the posterior articulation. A part of the spine of this hæmal arch is preserved nearly in its true position.

The foregoing comparisons show that all the general characters of the Lacertian type of the vertebrate skeleton are presented by the *Dolichosaurus*: they are most modified in the cervical region, where the Ophidian type is rather followed in the number and size of the vertebræ, and in the size and shape of the ribs: a less decided approach, but one still indicating an affinity to the Ophidians, is made by the unusual length of the slender trunk, which includes, from the skull to the sacrum, not fewer than fifty-seven vertebræ, and is not less than eighteen inches in length. The smallness of the head accords with the long and slender proportions of the neck, and must have added to the snake-like appearance of this early example of procœlian lizard. But the complete and typically Lacertian organisation of the scapular and pelvic arches, and

of their locomotive appendages, prove that the *Dolichosaurus* was more strictly a lacertine Saurian than the existing genera, *Pseudopus*, *Bipes* and *Ophisaurus*, which effect the transition from the Lizards to the Snakes.

Tribe, NATANTIA.

Genus, MOSASAURUS.

The history of the discovery by Major Drouin, in 1766, of the gigantic marine lizard called by Conybeare *Mosasaurus*, together with an account of the nature of the formation in which its remains occur, are fully given by Cuvier, in his 'Recherches sur les Ossemens Fossiles,' tom. v, pt. ii, pp. 310—320. The largest species of *Mosasaurus* is calculated to have been at least twenty-five feet in length, and derives its name from the locality on the banks of the Meuse, near Maestricht, where the newer cretaceous deposits occur in which its remains were found. The finest and most perfect skull of the animal was discovered in the quarries at St. Peter's Mount. Camper saw it in 1785, in the house of the Rev. Dr. Goddin, canon of the chapter of Maestricht, and writes:—"In this the greater part of both the upper and under maxillary bones is entire, and a bone, with small teeth, belonging to the palate; by which it appears, the animal had not only teeth in the jaw-bones, but also in the throat, as several fishes have, but which are never found in the mouth of crocodiles;"* and Camper naively expresses his surprise that notwithstanding all his endeavours to convince his friends, he "never could prevail upon them to adopt his opinion, that these bones belonged to the physeteres or respiring fishes." In fact, neither the physeter nor any other cetacean or respiring fish, have teeth on the palate any more than the crocodiles. M. Adrien Camper, the son of the great anatomist, first pointed out the affinities of the Mosasaurus to the *Monitors* and *Iguana*,† in which latter genus, as in *Amblyrhynchus*, small teeth are present on the same bones, viz., the pterygoid, in which they occur in the Mosasaurus. The large fossil skull of the Mosasaurus was yielded up by the Canon Goddin to the French army, after the capture of Maestricht by the forces of the Republic in 1795, and it was transported to the Museum of the Garden of Plants at Paris, where it still remains. M. Faujas St. Fond, who, in his capacity as Commissary for the Sciences of the "Army of the North," transacted the transfer of the famous specimen, gives the following account of its discovery:—

* Philosophical Transactions, 1786, p. 444.

† In a letter to M. Cuvier, in the 'Bulletin de la Société Philomathique,' Fructidor, An. viii (1790); and in the 'Journal de Physique,' Vendemiaire, An. ix (1791). See also his 'Mémoire sur quelques parties moins connues du squelette des Sauriens Fossiles de Maestricht,' in the 'Annales du Muséum d'Hist. Nat.,' tom. xix (1812), p. 215.

"In one of the great galleries or subterraneous quarries in which the cretaceous stone of St. Peter's Mount is worked, about five hundred paces from the entrance, and ninety feet below the surface, the quarry-men exposed part of the skull of a large animal in a block of the stone which they were engaged in detaching. On this discovery they suspended their work, and went to inform Dr. Hoffmann, surgeon to the forces at Maestricht, who for some years had been collecting the fossils from this quarry, remunerating the workmen liberally for the discovery and preservation of them. Dr. Hoffmann, arriving at the spot, saw with extreme pleasure the indications of a magnificent specimen; he directed the operations of the men, so that they worked out the block without injury to the fossil, and he then with his own hands cleared away, by degrees, the yielding matrix, and exposed the extraordinary jaws and teeth, which have since been the subject of so many drawings,* descriptions, and discussions. This fine specimen which Hoffmann had transported with so much satisfaction to his collection, soon, however, became a source of much chagrin to him. Dr. Goddin, one of the canons of Maestricht, who owned the surface of the soil beneath which was the quarry whence the fossil had been obtained, when the fame of the specimen reached his ears, pleaded certain feudal rights in support of his claim to it. Hoffmann resisted, and the canon went to law. The whole chapter supported their reverend brother, and the decree ultimately went against the poor surgeon, who lost both his specimen and his money, for he was made to pay the costs of the action." M. Faujas St. Fond, the instrument of the more forcible and summary mode by which the French seized upon the unique specimen, moralizes in his narrative of the robbery in the following strain:—"The canon Goddin, leaving all remorse to the judges who had pronounced the iniquitous sentence, became the happy and contented possessor of this unique example of its kind. But justice, though tardy, comes at last." (!) M. Faujas then proceeds to narrate how, in the bombardment of the town, directions were given to spare the suburb in which the famous fossil was understood to be preserved; and how, after the capitulation, the French grenadiers discovered, seized, and bore off the specimen in triumph to the commissarial residence; and concludes by a pæan to the "excellent soldiers who always knew how to appreciate and respect the monuments of the arts and sciences."†

The occurrence of remains of the *Mosasaurus* in England was first noticed by, Dr. Mantell, in a work entitled 'The Geology of the South-east of England," 8vo, 1833, in which woodcuts are given at p. 146, of a dorsal vertebræ, and of two caudal vertebræ, which were found in the upper (?) chalk, near Lewes. The body of the dorsal vertebra is said to be "about two inches long, and 1·4 inch high;" and the

* First by Buchoz, in his 'Dons de la Nature,' tab. 68; then by Faujas St. Fond, in plate iv of his 'Histoire Naturelle de la Montagne de St. Pierre;' afterwards by Cuvier, in his 'Ossemens Fossiles,' tom. v, pt. ii, pl. xviii; copied by Buckland in the 'Bridgewater Treatise,' pl. 20.

† Tom. cit., p. 62.

mutilated body of a vertebra of these dimensions, together with the two caudal vertebræ, form part of that collection which was sold by Dr. Mantell to the British Museum. No proof is given that these vertebræ belong to the same species as the *Mosasaurus Hoffmanni:* the dorsal vertebræ of the great Mosasaurus of Maestricht are more than double the size of the one above cited, which, in the complete anchylosis of the neural arch, would seem to have belonged to a mature individual of that cold-blooded genus.

Subsequent discoveries of Mosasaurian Fossils in the English cretaceous deposits have enabled the comparison with the specific characters of the *Mosasaurus* of Maestricht, and of that from the Green-sand of North America, to be carried out satisfactorily, especially in reference to the modifications of the teeth.

MOSASAURUS GRACILIS, *Owen.* *Lacertians,* Plate 1, figs. 1, 2, and 3. Pl. 2, figs. 1, 2, 3, 4, and 5. Pl. 9, figs. 7, 8, and 9.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Deposits of Sussex.' T. XXXIX.

CUVIER,* in his account of the great *Mosasaurus* of Maëstricht, which is entered in the catalogues of M. v. Meyer and M. Pictet, under the synonyms *M. Camperi* and *M. Hoffmanni*, states that "all the teeth are pyramidal, a little curved, with their external surface flat ('plane') and divided by two sharp ridges from the internal surface, which is round or rather semi-conical." Messrs. Von Meyer† and Pictet‡ repeat Cuvier's description of the external characters of the crowns of the teeth; the one says, "ihre Aussenseite ist eben"—their outer side is flat or level; the other, "leur face externe est plane." My description§ of the teeth of the Maestricht Mosasaurus, in which it is stated that "their outer side is nearly plane, or slightly convex," was founded on an examination of the magnificent fossil skull in the Parisian Museum, the original of Cuvier's description;—and the contour of the base of the crown of a maxillary tooth of the *Mosasaurus Hoffmanni* given in Pl. 10, fig. 7, is taken by accurate admeasurement from a perfect specimen from the Maëstricht chalk: the enamelled crown of this tooth was two inches (five centimeters) in length; the rest of the tooth was formed by the enlarged coarse osseous fang; the total length of the tooth being four inches ten lines (twelve centimeters and a half). Dr. A. Goldfuss, in his highly interesting and instructive description‖ of the skull and teeth of the *Mosasaurus Maximiliani,* accurately describes and figures the finely dentated character of the two opposite longitudinal ridges of the crown; but the feeble indications of angles observable in some of the

* Annales. du Muséum d'Hist. Nat., xii, 1808. Ossemens Fossiles, 4to, v, pt. ii, p. 322.

† Palæologica, p. 219.

‡ Traité élementaire de Paléontologie, ii, p. 63.

§ Odontography, 4to, p. 258.

‖ Nova Acta Acad. Nat. Cur., t. xxi, p. 175.

teeth, those of the upper jaw chiefly, of the *Mosasaurus Hoffmanni*, do not bear out the term "polygonal" which he applies to the crowns of the teeth of that species, as well as to those of his *Mosasaurus Maximiliani;* still less can I find these angles so constant and regular as to divide the outer surface of the crown into five, and the inner surface into seven facets; nor have I seen in any maxillary or mandibular tooth of *Mosasaurus Hoffmanni* that near equality of extent and convexity between the inner and outer surfaces of the crown, which Dr. A. Goldfuss describes (p. 178) and figures in Tab. IX, fig. 4, of the memoir above cited. If that figure accurately represents a maxillary tooth of the same species of *Mosasaurus* as the one described by Cuvier and recorded by V. Meyer and Pictet under the name of *M. Camperi* and *Hoffmanni;* and if the outer surface of the crown is ever flat or level, the range of variety between the two extremes of flatness and convexity is greater than I have yet found in any of the equally well-marked forms of teeth in other fossil reptiles.

The teeth in the specimens of upper and lower jaw of the species of Mosasaur from the chalk-pit at Offham, Sussex, now in the Museum of Henry Catt, Esq., of Brighton, and figured of the natural size in Pl. 2, fig. 1 and 1*a*, equally differ from the typical form of tooth of the *Mosasaurus Hoffmanni*, and from those of the *Mosasaurus Maximiliani*, Pl. 10, fig. 8: the outer surface of the crowns of the mandibular teeth of *Mosasaurus gracilis* are more convex than those of *Mos. Hoffmanni*, and are less convex than those of *Mos. Maximiliani:* not any of the teeth of *Mosasaurus gracilis* present that angular disposition of the enamel which gives the polygonal form to the pyramidal crowns of the teeth of the *Mos. Maximiliani.* The lower jaw, Pl. 2, fig. 1, is more slender, less deep in proportion to its length, than in the great Maestricht Mosasaur, and the hinder teeth are relatively smaller and closer together; I have proposed, therefore, to indicate the species by the name of *Mosasaurus gracilis.* The general form of the crown of the teeth in *Mos. gracilis* is shown at *a*, *b*, and *c*, fig. 1; an exact contour of the crown a little above its base is given at Pl. 10, fig. 9. The smooth and polished enamel; the inequality of the outer and inner sides of the crown, such as it is; the implanted fang of the tooth thickly coated by a coarse osseous cement; the general anchylosis of the fang to the bony walls of the socket, which rise in a pyramidal form from alveolar border of the jaw; all manifest the peculiar generic characters of the great acrodont marine lizard, *Mosasaurus.* The maturity of the individual from which the present specimen (Pl. 2, fig. 1) has been derived, cannot be inferred from the solidification and complete development of the anchylosed fangs of the teeth in a class of animals in which those organs are repeatedly shed and renewed: the worn-out teeth, in course of displacement, of the young crocodile, with their alveoli, present in miniature all the senile characters of the corresponding teeth of the mature and aged animal. If, however, the specimen of Mosasaur in question should be adult, it would derive a well-marked specific character from its diminutive size as compared with the *Mosasaurus Hoffmanni* or *Mos. Maximiliani;* being only one third the size of the latter,

and one fourth that of the former species. But the characters of immaturity are not manifested by the cold-blooded animals in their osseous and dental systems as they are in the warm-blooded and higher organised mammalia.*

In all the teeth of the *Mosasaurus gracilis* in which the crown is broken, the remains of the pulp-cavity are exposed in the centre of its base: but the immaturity of the specimen is not demonstrated by this character; for, in the largest sized teeth of the *Mosasaurus Hoffmanni*, even in one with a completely developed fang, measuring with the crown nearly five inches in length, I have found a pulp-cavity extending from the base of the crown into the expanded fang, but becoming almost obliterated at the base of the fang. The cast of the crown of a still larger tooth of a Mosasaurus from the green-sand of New Jersey, U.S., also shows the remains of a pulp-cavity at its base. This cavity becomes filled in the fossil specimens with the matrix, which is usually chalk; but sometimes the cavity, like the air-chambers of polythalamous shells, is filled with silex.

The number of teeth in each ramus of the lower jaw of *Mosasaurus gracilis* seems not to have exceeded twelve. In *Mosasaurus Maximiliani* they are reckoned at eleven;† in *Mosasaurus Hoffmanni* at fourteen; and in this species they are placed closer together than in the *Mos. gracilis*, as may be seen by comparing figure 1 of Pl. 2 with that of the lower jaw given by Camper in the 'Philosophical Transactions' for 1786, tab. xvi, which is copied by Faujas St. Fond, in pl. vi, of his 'Histoire de la Montagne de St. Pierre.'‡ The posterior teeth are rather smaller than the others in *Mosasaurus gracilis.* At the fore part of the jaw the implanted and anchylosed base of the teeth extends through about half the vertical diameter of the jaw; at the posterior part of the series the fangs sink into one third or one fourth the depth of the jaw. The canal, which, as in the crocodile, extends below and along the inner side of the bases of the sockets and anchylosed fangs, is shown, filled by chalk, at *d,* fig. 1. Traces of the vascular foramina along the outer side of the jaw are visible in the right dentary piece, the outer side of which is exposed: the "splenial" ("opercular," Cuvier,) element is shown at *x,* fig. 1, on the left ramus.

In the portion of the left superior maxillary bone (Pl. 2, fig. 1 *a*) all the teeth are, unluckily, too much broken or abraded to give an idea of the precise form of their crowns; they are rather more compressed at their base than in *Mosasaurus Hoffmanni:* the posterior ridge is much less developed, and the whole of the posterior longitudinally concave border is more transversely convex than in *Mosasaurus Hoffmanni* or *Mos. Maximiliani.* There is as little indication of the angular or polygonal

* Dr. Goldfuss infers the maturity of his *Mosasaurus Maximiliani* from the characters, of which the inadequacy is explained above. "Die vollständige Verknöcherung aller Theile, so wie die häufige bemerkbare Aussfullung der Zähne beweisen, dass das Individuum seine vollständige Ausbildung und mit dieser nur die halbe länge des *Mosasaurus Hoffmanni* erreicht hatte." (Loc. cit., p. 177.)

† Goldfuss, loc. cit. p. 178.

‡ Cuvier, loc. cit. p. 320.

structure in these teeth as in those of the lower jaw; but the enamel shows some longitudinal striations.

All the vertebræ of the *Mosasaurus*, according to Cuvier, are concave at the fore part, convex at the hind part of their bodies; the convexity and concavity being greatest on the anterior vertebræ. The foremost of these are characterised by an inferior process or "hypapophysis," developed from the middle of the lower surface of the centrum: they have two transverse and four articular processes, and a long compressed upper or neural spine. The centrum is longer than it is broad, and broader than it is high; the terminal articular surfaces are transversely oval or reniform. Such are the characters of the last cervical or first dorsal vertebræ. The middle dorsal vertebræ are like these, but have no hypapophysis. Then follow vertebræ which have no articular or oblique processes (zygapophyses), but have longer and flatter transverse processes (diapophyses), and terminal articular surfaces of a pentangular form, or of a triangular form with the base downwards (see Pl. 1, fig. 5). Next come vertebræ with diapophyses and a pair of inferior processes (hypapophyses) for the articulation of chevron-bones (hæmapophyses); afterwards vertebræ without transverse processes and with large anchylosed chevron-bones (hæmapophyses); and finally vertebræ devoid of all processes whatever.

The vertebræ discovered in the Kentish Chalk, with the jaws and teeth above described, and of corresponding proportions to those parts which we observe in the vertebræ of the *Mosasaurus Hoffmanni*, present all the generic vertebral characters of that Lacertian genus, and correspond with the third and sixth kind, or with the posterior dorsal and the anterior caudal vertebræ, as defined by Cuvier. But the terminal articulations of the centrum of the dorsal vertebræ of *Mosasaurus gracilis* present a full oval (not elliptical) form, the long axis of which is vertical and the great end downwards (Pl. 2, fig. 4). The length of the centrum (*ib.*, fig. 3), which is three centimeters and a half, or one inch and five lines, exceeds the breadth; but this is equalled by the height of the centrum. The diapophyses in fig. 2, *d*, are broken away; in fig. 3 it is uncertain whether the surface be a fractured one, or whether it is a natural cavity for the rib; the analogy of *Mosasaurus Hoffmanni* favours the former view of it. The neural arch (fig. 3, *n*) is anchylosed to the centrum, as in the larger species of *Mosasaurus*. I can perceive only a feeble indication of zygapophyses, which shows that the vertebra (figs. 2 and 3) comes from the posterior region of the back. The neural canal (fig. 4, *n*) is small and triangular; a sharp longitudinal ridge rises from the middle of its floor, and on each side of this there is a vascular canal descending vertically into the substance of the centrum; this substance presents a coarse fibro-cancellous texture; the areolæ extended longitudinally, and decreasing much in size at the ends of the centrum. The outer surface of the vertebra is smooth; the margins of the anterior articular concavity are sharp.

The vertebra (fig. 2) shows, by the lower position of the diapophysis (*d*), that it

comes from a more posterior position of the spine than that represented in fig. 3. Figs. 5 and 5 *a* give views (upside down) of a caudal vertebra, which demonstrates another Mosasaurian character in the anchylosis of the hæmapophyses or chevron-bones to the centrum, as in the posterior caudal vertebræ of *Mosasaurus Hoffmanni;* but the hæmal canal (fig. 5 *a, h*) is relatively wider, and the entire centrum is much longer than in the corresponding kind of vertebra figured by Cuvier* or by Faujas St. Fond.†

Three views of the body of a vertebra of the *Mosasaurus gracilis*, discovered by the Rev. H. Hooper, M.A., distinguished by his geological researches in the neighbourhood of Lewes and Brighton, are given in Pl. 9, figs. 7, 8, and 9. This specimen is from the Sotheram Chalk-pit, near Lewes.

From the genus *Leiodon*‡ (Pl. 10, fig. 5, 5**) the *Mosasaurus gracilis* (Ib. fig. 9) differs, like the *Mosasaurus Hoffmanni* (Ib. fig. 7), in the inequality of the two sides of the crown of the teeth, which are bounded or divided by the anterior and posterior ridges. The *Mosasaurus Maximiliani* (Ib. fig. 8) differs from the genus *Leiodon* in the polygonal character of the crowns of the teeth.

The interest which must be excited in the Naturalist and Palæontologist by an extinct Saurian, essentially organised according to the Lacertian type, but developed on a scale surpassing that of the largest existing Crocodiles, and especially modified, as it seems, for aquatic life, leads me to believe, that any additional facts tending to complete its restoration will here be acceptable, although they may not have been afforded by fossils from British strata. In the formations of the Cretaceous Period in North America, answering in mineralogical characters to our Green-sands, though probably contemporaneous with the newest chalk deposits of Europe, many fine examples of *Mosasaurus*, of the species called by Goldfuss, *Mos. Maximiliani*, have been found, and the discovery affords a highly instructive instance of the coexistence of particular forms of fossil Reptilia in remote parts of the earth, at the same geological epoch. In a series of remains of the *Mosasaurus Maximiliani*, from a Green-sand formation at New Jersey, United States, kindly submitted to my examination by Professor Henry Rogers, of Pennsylvania, I detected the basioccipital bone of the cranium, which gave additional evidence of the Lacertian affinities of the *Mosasaurus*, and new proof of the Cuvierian law of correlation of organic structures. This basioccipital bone, which is figured in the 'Quarterly Journal of the Geological Society,' November, 1849, pl. x, fig. 5, was three inches and a half in length, and four inches nine lines in extreme breadth. It resembled the centrum of the "vertebra dentata" of the *Crocodilia*, in being convex behind and flattened in front. The convexity formed the inferior and major part of the occipital condyle, which must have been reniform, the angles being superior, and formed by the

* Cuvier, loc. cit., pl. xix, fig. 6, *A*, *B*. † Loc. cit., pl. viii.

‡ Odontography, 4to, p. 261, pl. 72, figs. 1 and 2.

exoccipitals. The rough sutural surfaces for the articulation of these elements were divided by a deep and narrow channel, which gradually expanded towards the condyle. The anterior flat vertical articular surface of the basioccipital was smooth, indicative of a persistent harmonia between it and the basisphenoid, analogous to that which exists between the centrum of the axis and the odontoid process. Two very thick and short exogenous processes (hypapophyses) diverge from the under part of the anterior half of the basioccipital, and terminate in oblique and slightly convex surfaces, irregularly pitted; they resemble the hypapophyses sent off from the basisphenoid in the great Monitor (*Varanus*), against which the pterygoids abut. This form and structure of the basioccipital of the Mosasaurus harmonizes with the other indications of its Lacertian affinities. The basi-occipital in the *Crocodilia* sends down a single hypapophysis.

No part of the organisation of the *Mosasaurus* is so little known as that of the locomotive extremities. Cuvier gives copies of drawings which had been transmitted to him of a portion of the scapula,* clavicle,† and coracoid,‡ of a portion of a long bone, which he likens to the cubitus of a Monitor,§ and of an os pubis,|| all of which he believes to have belonged to the *Mosasaurus*.

The portion of the ulna would indicate, Cuvier remarks, that the *Mosasaurus* had moderately elevated extremities;¶ but he adds that "the bones of the fore and hind feet, so far as they are known, would seem, on the contrary, to have belonged to a kind of contracted fin, like that in the dolphin or *Plesiosaur*.** He, however, figures two bones comparable with the two principal bones of the carpus of the Crocodile,†† and which one would scarcely expect to be associated with metacarpals and phalanges like those of the *Enaliosaurs*. And if the ungual phalanx, figured in pl. xx, fig. 21, of the 'Ossemen's Fossiles,' be rightly attributed to the *Mosasaurus*, it determines the question in the negative, as to whether that Lacertian reptile had plesiosaurian paddles; the phalanx in question much resembles that in the British Museum (No. 384, Mantellian Catalogue), which has been described as "The Horn of the *Iguanodon*." The phalanx represented in Pl. xx, fig. 5, of the same work, with almost flat articular ends, must have belonged to a natatory form of foot; but as large Chelonians were associated with the *Mosasaurus* in the Maestricht beds, it would be rash to conclude that this phalanx absolutely belonged to the *Mosasaurus*. Cuvier, in fact, sums up by admitting the hesitation which he feels in offering his conjectures as to the nature of the extremities of the *Mosasaurus*, which were founded on the inspection of drawings

* Ossemen's Fossiles, tom. v, pt. 2, 4to, pl. xix, fig. 9. † Ib., fig. 14.
‡ Ib., fig. 15. § Ib., pl. xx, fig. 24. || Ib., pl. xix, fig. 10.
¶ "Il annoncerait que ses extremités étaient assez élevées." (Ib., p. 336.)
** "Les os des mains et des pieds, autant qu'on les connaît, sembleraient au contraire avoir appartenu à des espèces de nageoires assez contractées, et plus ou moins semblables à celles des dauphins ou des plésiosaurus." (Ib. p. 386.) †† Ib., pl. xx, figs. 4 and 5.

only, for he says the immediate comparison of the bones themselves would hardly suffice, so great is the diversity and so small the precision of the forms of those bones in reptiles.*

M. Pictet, in the second volume of his 'Traité Elémentaire de Paléontologie,' 8vo., 1845, terminates his brief summary of the characters of the *Mosasaurus*, by stating:— "Les membres paraissent avoir été terminés par des nageoires aplaties," (p. 62.)

In the collection of Saurian fossils submitted to me by Professor Henry Rogers were some bones of the extremities, showing the Lacertian type of structure, and agreeing in colour, petrified condition, and proportional size with the vertebræ and teeth of the *Mosasaurus* from the same Green-sand formation. They were too large to be attributed to the Crocodilian species indicated by the vertebræ from the same formation. I subjoin, therefore, a brief description of these interesting fossils which appear to me to throw additional light on the structure of the locomotive organs of the *Mosasaurus*.

The first of these bones gave the following dimensions:—

	Feet.	Inches.
Extreme length	2	8
Extreme breadth of the broader end	0	8
Breadth of narrower end of the same bone (imperfect)	0	4½

The best preserved extremity of this long bone is expanded and subcompressed, like the lower end of the fibula of the *Varanus*, one part of this extremity being produced into an obtuse angle. The extremity is smooth, slightly concave transversely on one side, more irregular on the opposite side, with a thick prominent border opposite to the produced angle. The shaft of the bone has an irregular full, oval, transverse section with dense walls of concentric plates of bone, eight or nine lines thick, surrounding a medullary cavity, one inch nine lines in diameter. The shaft is very slightly bent. The opposite extremity which gradually expands, preserving the general form of the shaft, exhibits a strong longitudinal ridge of six inches in extent, but which subsides before it reaches the articular end. Only a portion of this end is preserved, which is slightly and irregularly convex.

The second long bone of the extremity yields the following dimensions:—

	Feet.	Inches.
Extreme length	2	5
Breadth round the upper (?) articulating surface	0	4½
Depth of articulating surface	0	3¼
Breadth of lower (?) end (imperfect)	0	3

This bone, therefore, equals in length the preceding, but becomes more attenuate in the middle than any of the long bones in the existing *Saurians*; one extremity is

* Loc. cit., p. 357.

compressed, and terminates in a slightly convex, thick, smooth articular border. Nine or ten inches below this, the shaft, slightly increasing in breadth and decreasing in thickness, presents a thick, rough, and prominent ridge, three inches and a half in length, apparently for the attachment of some strong muscle; behind this ridge the shaft contracts to a diameter of one inch nine lines, and to a circumference of four inches six lines. At ten inches from the distal end it increases in thickness, assumes a trihedral form, with one edge produced and convex, subsiding above the articular end, which is in the form of a simple convex condyle, not excavated for a trochlear joint in the middle, but with an irregular branched impression or smooth groove at that part: the articular surface extends upon the fore and the back part of the shaft, about two inches six lines from the end, contracting posteriorly, and with a convex border anteriorly above, where there is a shallow semilunar depression. There is a very deep large hemispheric pit on each side above this condyle. There is no medullary cavity in this bone.

These two long bones are more like the tibia and fibula of the larger lizards than the radius and ulna: there can be little doubt that they belong either to the leg or to the antibrachium, but they differ too much in shape from any of the bones of those segments in the larger lizards, with which I have been able to compare them, to encourage me to hazard a positive determination. I should be disposed to ascribe them, from their length and slenderness, to the hind leg. They are more Lacertian than Crocodilian in their general character; and they belong with great probability to the *Mosasaurus*.

A metacarpal or metatarsal bone of the same reptile gives the following dimensions:—

	Feet.	Inches.
Extreme length	1	8
Extreme breadth of the broader articulating surface or upper end	0	$4\frac{3}{4}$
Central depth of ditto	0	$3\frac{1}{4}$
Breadth of lower end	0	3

The proximal or upper end is suddenly expanded, with an undulated or partly convex partly concave articular surface, nearly flat, at right angles to the shaft; subtriangular with the angles rounded off, or reniform on account of the deep notch posteriorly, below which there is a depression. A ridge is continued from the shaft upon two of the angles, which gives a subhemispheric section of the shaft at six inches from the head. Here a medullary cavity nine lines in diameter is exposed. One half of the parietes of the middle third of the shaft of this bone is preserved, which shows a continuation of the medullary cavity and the development of an angular ridge from the shaft, which subsides about six inches from the distal end. This end slightly expands into a simple convex condyle, with the articular surface

irregularly grooved, and with a large deep hemispheric pit on one side above the surface, but not on the other.

The above-described long bones were taken back by Professor Rogers to America; the following specimen he liberally permitted me to retain.

A metacarpal or metatarsal bone rather larger than the preceding, with the notch at the proximal end much less deep. The angular border or ridge, continued from one of the posterior rounded angles of the articular surface, quickly subsides; that from the other angle is continued down from the middle of the shaft, giving it an oval transverse section. The fracture of the shaft, nine inches from the head of the bone, exposes an oval medullary cavity, nine lines in the long diameter. The longitudinal ridge is developed from the distal half of the bone, as in the former, and it terminates in a simple convex condyle with the grooved sculpturing upon the articular surface, and with the large deep hemispheric pit for a ligament, on one side of the trochlea, and a large shallow notch on the opposite side.

The following two bones of the toes conform to the Lacertian type, and not to that of the *Enaliosauria*. The first is a proximal phalanx of a toe of apparently the same Saurian as the bone last described. The proximal articular surface appears to have been subcircular, very slightly concave, with a few shallow pits and grooves in the middle, like those on the end of the metatarsal. The shaft gradually contracts, and becomes more convex in front than behind; it subsides into a shallow depression above the forepart of the distal trochlea, on each side of which there is a large and deep ligamentous pit. Its dimensions are as follows:

	Inches.
Extreme length	5
Breadth of upper articulating surface	$2\frac{1}{2}$
Depth of ditto	$2\frac{1}{2}$
Breadth of lower articulating surface	$1\frac{3}{4}$
Depth of ditto	2

The second specimen is a second phalanx of apparently the same toe; having an expanded, concave, proximal, articulating surface, adapted to the distal surface of the preceding bone; and terminated by an oblique broad convex trochlear articulation. Its dimensions are as follows:

	Inches.
Extreme length	$3\frac{1}{2}$
Breadth of upper articulating surface	$2\frac{1}{4}$
Depth of ditto	2
Breadth of lower articulating surface	2
Depth of ditto	$1\frac{1}{2}$

On the highly probable supposition that the above-described long bones belong to the *Mosasaurus*, they indicate the extremities of that gigantic lizard to have been

organised according to the type of the existing *Lacertilia* and not of the *Enaliosauria* or *Cetacea*. But a foot so organised for crawling on land might, nevertheless, by the webbed union of the large and long unguiculate claws, have been well adapted, like the feet of the Amblyrhynchus and Alligator, for swimming; and the modifications of the vertebral column, especially of the long and deep tail of the *Mosasaur*, clearly prove it to have been more strictly aquatic in its habits than any known existing lizard.*

The vertebra from the Chalk near Lewes (Pl. 1, figs. 1 and 2) above alluded to, which is the subject of the cut, No. 2, p. 146, of Dr. Mantell's 'Geology of the South-East of England,' is one of those posterior dorsal or lumbar vertebræ, in which the diapophysis (*d*) arises from near the middle of the side of the centrum, and has a depressed flattened form, at its origin, instead of the thicker subcompressed form that characterises the same process in the anterior dorsal vertebræ. The specimen in question is much mutilated; both the neurapophyses, *n*, the diapophyses, *d*, and part of the left side of the centrum, are broken away; but the rarity of such evidences of the Mosasaurian genus in our English Chalk, and the historical interest attached to this, which is one of the first specimens discovered, has induced me to give an accurate figure of it in Pl. 1, fig. 4, together with one of the homologous vertebræ of the Maëstricht species (fig. 4), which is preserved in the British Museum. The specimen from Lewes presents the following dimensions:—

	Inches.	Lines.
Length of the centrum	2	0
Vertical diameter of ditto	1	4
Transverse diameter of ditto	1	6
Length of the base of the neural arch	1	8

The neural arch, *n*, has completely coalesced with the centrum: it terminates behind, about four lines from the convex articular end of the centrum. The marginal circumference of that surface, fig. 2, has been worn away, but it evidently presented a more obovate and less triangular figure than in the *Mosasaurus Hoffmanni*, fig. 5. The fractured base of the diapophysis, shown at *d*, fig. 1, is situated lower than half-way down the side of the centrum.

The two caudal vertebræ (Pl. 1, fig. 3) have been retained in natural juxtaposition in the same block of Chalk. Both the neural (*n*) and hæmal (*h*) arches have coalesced with the centrum without any trace of the primitive sutures, the antero-posterior extent of the neurapophysis is relatively shorter than in the more advanced vertebra,

* M. Hermann von Meyer, in his comprehensive and useful summary of Fossil Remains, entitled 'Palæologica,' 8vo, 1832, classifies the *Mosasaurus* with the *Plesiosaurus*, in the Order of *Sauria*, characterised by fins. ("Saurier mit flossartigen Gliedmassen," p. 201.)

as is shown by fig. 6 as compared with fig. 4, and by the following admeasurements of one of the caudal vertebræ :—

	Inch.	Lines.
Length of the centrum	1	7
Vertical diameter of the convex end	1	5
Transverse diameter of ditto	1	3
Length of the base of the neural arch	1	0
Length of the base of the hæmal arch	0	9

The hæmapophysis (*h*) swells outwards at its origin, before it bends downwards, backwards, and inwards to unite with its fellow in order to complete the arch. The area or span of this arch has been considerable, as in the vertebra, fig. 5 *a*, Pl. 2, and as it is in the *Mosasaurus Hoffmanni:* it is probable that the spinous process continued from it had a corresponding remarkable length, but of this the fractured condition of the specimen affords no proof. The lateral surface of the centrum is smooth, with many small vascular perforations. There is a slight but well-marked rising above the base of the hæmapophysis, at *d*, fig. 3, Pl. 1, which seems to indicate a last rudiment of the diapophysis. A narrow vertical ridge (*r*) extends about two lines from the border of the posterior convex surface, as if it were indicative of the limits of an epiphysis which had formed that surface. The border of the anterior concave surface has been worn or broken away. A linear impression gives also an indication of an epiphysis in the dorsal vertebra of the *Mosasaurus Hoffmanni.* The slight degree of concavity and convexity of the terminal articular surfaces of the centrum in these vertebræ is characteristic of the genus. In their special characters, the small vertebræ from Lewes correspond with the vertebræ attributed to the *Mosasaurus gracilis*, which are longer and more slender than those of the *Mosasaurus Hoffmanni.*

Genus.—Leiodon, *Owen.*

'Odontography,' p. 261, pl. lxxii, figs. 1 and 2.

'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 144.

The teeth from the chalk of Norfolk, surmised by Dr. Mantell, from "their symmetrical, conical form, and other characters," to belong to an unknown reptile, or to a sauroid fish;* and described and figured in my 'Odontography'† as characteristic of a new genus of Mosasauroid Reptiles, under the name of *Leiodon*,‡ presented

* Wonders of Geology, ed. 1839, vol. i, p. 339.

† Vol. i, p. 261, pl. lxxii, figs. 1 and 2.

‡ Λειος, smooth, οδοῦς, tooth.

the same acrodont type of dentition as in *Mosasaurus* and *Geosaurus*, but differed in their closer arrangement and from the former, especially, in the shape of the crown, of which the outer side was as convex as the inner side, the transverse section being an ellipse with pointed ends, which latter corresponded with two opposite trenchant edges dividing the outer from the inner side of the crown. This was covered by a smooth enamel without any indications of minor ridges or facets: the apex of the crown was sharp-pointed; the body of the crown slightly recurved; and its base expanded into a thick fang of a circular form, which was anchylosed to a short conical process of the alveolar border of the jaw.

Deducing the generic dental characters of *Mosasaurus* from the magnificent example of the jaws and pterygoid bones, which passed from Dr. Hoffmann's collection to that of the Canon Goddin, and ultimately to the Museum of the Garden of Plants at Paris, the deviation in the teeth in question from the inequilateral facetted character of the crowns of the maxillary and mandibular teeth of that specimen was so great, as to lead me to infer that these teeth from the English chalk belonged to a distinct genus of the same family of the Lacertine order; unless, indeed, they might be pterygoid teeth of a species of *Mosasaurus*, distinct from the *Mosasaurus Hoffmanni*. After a rigid comparison in reference to this question, I was led to the conclusion that they were not pterygoid, but maxillary teeth, and I therefore described them under the name of *Leiodon anceps*. The general results of that comparison, which would have been out of place in a systematic Treatise of Teeth in general, will here be requisite.

LEIODON ANCEPS, *Owen*. Lacertians, Plate 10.

'Odontography,' 1840, vol. i, p. 261; vol. ii, pl. 72, figs. 1 & 2.
MOSASAURUS STENODON. *Charlesworth.* The London Geological Journal, 1846, p. 23. pls. 4 and 6.

Baron Cuvier, after a close and accurate description of the pterygoid bones of the great *Mosasaurus Hoffmanni*, concludes by stating, that "each of these bones seemed to have supported eight teeth, which grew, became attached, and were replaced, like the teeth of the jaws, but were much smaller."* They also differ from the jaw-teeth by having their two sides less unequal in regard to their convexity; the inner side is almost as convex as that side of the maxillary teeth, but the outer side of the

* "Cet os paroît avoir porté dans notre animal fossile huit dents qui croissoient, se fixoient et se remplaçoient comme celles des mâchoires, quoique beaucoup plus petites." (Ossemens Fossiles, tom. v, pt. ii, p. 324, 4to, 1824.)

pterygoid teeth is more convex than the nearly flat outer side of the maxillary teeth. They resemble, in fact, in their transverse section, the lower maxillary teeth of the *Mosasaurus Dixoni*. The alveolar border to which the pterygoid teeth are attached in the *Mosasaurus Hoffmanni*, is moderately convex towards the cavity of the mouth; the alveolar tract is relatively thicker or broader than on the jaws, and the germs of the new pterygoid teeth appear almost like a second small row on the outer side of that row which is in place, being less close to the teeth they are destined to replace than they are in the maxillary series.

The teeth in question from the English Chalk, differed in the shape of their crowns from the pterygoid teeth of the *Mosasaurus Hoffmanni*, and the alveolar border to which they were attached, more resembled that of the dentary piece of the lower jaw. In the smoothness of the enamelled crown, its compressed elliptical form and trenchant borders, (Pl. 10, figs. 5, 6,) which, when magnified, presented a fine serration, the teeth in question, approached to the characters of those of *Geosaurus*, as much as they deviated from those of *Mosasaurus*. Both *Mosasaurus* and *Geosaurus* afford types of the acrodont mode of dental attachment. Had only the teeth and portions of the jaws of the *Geosaurus* been known they might have been registered, on such limited evidence, as having belonged to a species of *Mosasaurus* distinct from the *Mosasaurus Hoffmanni*, and the Anatomist, SOEMMERRING, even supposed that the *Geosaurus* might be merely the young of that species. But the differences in the shape of the teeth are associated with differences in the structure of the cranium, of the sclerotic, and, what is still more important, in that of the vertebræ themselves, which are sub-biconcave and contracted in the middle of the centrum. With these evidences, therefore, of the importance of the differences indicated by different forms of the teeth of the acrodont *Sauria*, one may be justified in the expectation that the *Leiodon* will prove to be a genus alike distinct from both *Mosasaurus* and *Geosaurus*, and, as probably tending to fill up the hiatus that divided those genera in the series of Acrodonts, as it was known to Cuvier.

The additional evidence which has been received in elucidation of this highly interesting family of Saurians, since the publication of my 'Odontography,' has tended to confirm the conclusions stated in that work relative to the *Leiodon anceps*. The *Mosasaurus* of the Green-sand Formations in North America, (Pl. 10, fig. 8,) has been satisfactorily shown in Professor Goldfuss's Memoir, to be a species distinct from that of the Cretaceous Deposits at Maestricht, (ib. fig. 7.) The maxillary teeth show the same generic characters, the two sides being unequal, but with specific modifications. The pterygoid teeth are ten in number on each pterygoid bone, attached in like manner to an alveolar border, which is convex both downwards and outwards: all the crowns of these pterygoid teeth had been unfortunately broken off and lost.

Mr. Charlesworth has described and figured in the first part of the 'London Geological Journal,' a portion of jaw-bone, with five teeth, of the *Leiodon anceps*, which

he states to have come into his possession from "one of the numerous chalk-pits on the Essex side of the Thames"—the side on which the county of Norfolk lies; and it appears that the teeth described and figured in my 'Odontography' are not only specifically identical, but once formed part of the same specimen, with that which he has since figured. This may well be, for in the mass of materials which I had been collecting for six years previous to the publication of my 'Odontography' I found the drawings, which are engraved in Pl. 72, figs. 1 and 2 of that work, marked 'from the chalk of Norfolk,' without any other memorandum, and I feel obliged to Mr. Charlesworth for having publicly supplied in 1846, what my memory in 1840 failed to do, viz., the reference to the individual to whom I had been indebted in 1835 for the loan of the originals of those drawings.

With regard to the question of the nature and affinities of the *Leiodon*, the additional evidence which the figures published by Mr. Charlesworth afford, is of value. The teeth in that specimen can only be referred to the genus *Mosasaurus*, as characterised by Cuvier and Goldfuss, on the supposition that they are 'pterygoid teeth.' But, in an extent of an alveolar tract of seven inches, and including five teeth, (Pl. 10, fig. 1,) that tract is slightly concave lengthwise, instead of being convex: and it wants the horizontal platform extended to the outside of the teeth in place, and supporting the nidus of their successors, which characterises the pterygoid bones (see fig. 4).

In my 'Odontography,' I have briefly noticed one of the most common conditions of fossil teeth, in which the pulp-cavity has not been obliterated by calcification of the pulp itself in the lifetime of the animal. Thus, in the section on the teeth of the *Ichthyosaurus*, it is described in the following passage. "The remains of the pulp, after the formation of the due quantity of dentine, became converted, as in the pleodont lizards, by a process of coarse ossification, into a reticulate, fibrous, or spongy bone; but it continued open at the crown after the basal part of the tooth was thus consolidated, as is shown in the longitudinal section, (Pl. 73, fig. 8,) wherein *a* is the pulp-cavity, filled with crystallized spath, *b* the ossified pulp at the base of the tooth." p. 279. In fig. 2*, Pl. 10, is reproduced Mr. Charlesworth's figure of the mass of similar siliceous spath, that, in like manner, filled the uncalcified part of the pulp-cavity of the tooth of the *Leiodon anceps*. Although I should not have called this "a very unlooked for condition of the interior of the tooth," I concur with the Editor of the 'London Geological Journal' in his hypothesis of the precipitation of the siliceous matter from a fluid. But, at the same time, I am fully conscious how transparent a veil such an hypothesis is to our ignorance as to the precise conditions of the precipitation of such matter in the interior of fossil teeth, in the medullary cavities of fossil bones, and in the closed chambers of many polythalamous shells. The only wonder connected with the fact illustrated in Pl. 10, figs. 2 and 2*, is, that any Geologist should deem it an unlooked for or extraordinary one.

I have described and figured some small detached crowns of the teeth of the *Leiodon*,

from the Chalk-pits of Sussex, in my friend Mr. Dixon's Geology of the Tertiary and Cretaceous Deposits of that County, Tab. XXXVII, figs. 10, 11, and 12. One of the finest and most characteristic teeth of this genus was discovered in the Chalk, during the cutting of the Brighton and Lewes Railway: it is figured in Pl. 10, figs. 6 and 6*, of the present Work, and is now in the fine Collection of Henry Catt, Esq., of Brighton.

CHAPTER III.

Order. *CROCODILIA.*

Genus.—Crocodilus? *Crocodilia*, Plate 30.

In the Museum of Mr. Saull, F.G.S., there is a small block of green-sand from the County of Sussex, containing several parts of a small, and apparently very young crocodile. The portion of the upper jaw, and of the right ramus of the lower jaw, (Pl. 30, figs. 1 and 2,) demonstrate the crocodilian shape and mode of implantation of the teeth, which have thick, subconical, obtuse crowns, and present proportions most resembling those of the *Goniopholis crassidens.** The alveolar border of the jaw has a similar wavy outline, and so differs from that in the Gavials and Teleosaurs, in which the alveolar border is straight. The sockets of the teeth, which are distinct at the anterior half of the jaws, run together at the posterior half, as in the Alligators and the young Crocodiles of the existing species. Several bony scutes are preserved, as, e. g., at *ss* fig. 3; none of which show the tooth-like process at one angle, which characterises many of the scutes in the *Goniopholis:* and as there is not a single centrum, or body of a vertebra to give the characters of the articular ends of that part, I am unable at present to determine the species. The femur, 65, is longer and more slender in proportion to the ischium, 63, than in the Nilotic or Indian Crocodiles: and the tibia, 66, and fibula, 67, are longer in proportion to the femur. This species evidently had the hind legs proportionably more developed than in existing *Crocodilia,* and better adapted for swimming,—a character which is observable in the Teleosaurs and some other Crocodiles of the secondary formations. At the same time it should be remembered that, in the Green-sand Formations of New Jersey, vertebræ of two species of Crocodiles or Alligators have been discovered by Professor Henry Rogers, constructed on the same procœlian type as those of existing species. See 'Quarterly Journal of the Geological Society,' January, 1849, p. 380, pl. x.

* Report on British Fossil Reptiles, Trans. Brit. Association, 1841, p. 69.

Genus.—Polyptychodon, *Owen.*

'Odontography,' 1840, vol. ii, p. 19, pl. 72, figs. 3 and 4.
'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 156.

Having described in the preceding pages of the present Section the fossil remains of the Class Reptilia, from the Chalk-formations, which, as in the case of the Mosasauroids, are either referable or most nearly allied to species long known as characteristic of those Formations; or which, as in the case of the *Chelonia*, and the smaller *Lacertilia* with procœlian vertebræ, are nearly allied to the Turtles and Lizards of the present day; I next pass to the consideration of those fossils which indicate a greater deviation from modern types of the order, and which are either new, or comparatively new to Science.

In collecting the materials for my 'Report on British Fossil Reptiles' I soon found that among the evidences of that class in the Cretaceous Deposits of England, a large species of Saurian was indicated by thick conical teeth, having the general characters of the teeth of the Crocodile, but distinguished by the more regular circular transverse section of the crown, the absence of two opposite larger ridges, and the presence of numerous close-set, narrow, longitudinal ridges, continued, in some specimens, of nearly equal length to within a short distance of the apex of the crown, but in more specimens, of unequal length; a comparatively small number only of the ridges extending to near the apex: a few of the largest specimens of the teeth presented fewer and more minute ridges, and a greater degree of smoothness and polish of the enamel. Without venturing to say how far this latter character in the largest tooth might be due to age, there was a general adherence of all these teeth to a type of form and structure, which differed to such a degree from the type of any other recent or fossil teeth, as to induce me to signify such difference by applying a generic name to the extinct Reptile to which they belonged; and I accordingly described and figured them in my 'Odontography' under the name of *Polyptychodon*,* in reference to their many-ridged or folded exterior.

Some of these teeth in their size, and most of them in their general aspect, resemble at first sight the teeth of the great Sauroid fish *Hypsodon*, of Agassiz, which are also found in the chalk: but those of *Polyptychodon* may be distinguished, generally, by the greater solidity of the crown, and the conformity of the structure of the dentine with that of the Crocodiles and Plesiosaurs: the ridges also on the exterior of the crown of the Hypsodon's teeth are alternately long and short, and end abruptly at different, but commonly greater distances from the apex of the tooth than in *Polypty-*

* Vol. ii, p. 19: from πολυς, many, πτύξ, a fold, οδους, a tooth.

chodon, the interspaces between the longer ridges widening as they approach the apex. The teeth of the *Polyptychodon* never offer any approach to opposite trenchant edges of the crown: but this part, presenting throughout its extent a transverse section of an almost circular form, (*Crocodilia*, Pl. 26, fig. 7, Pl. 29, fig. 3,) is slightly and regularly bent lengthwise, and is invested with a moderately thick layer of true enamel, of which substance the ridges are wholly composed, the surface of the outermost layer of dentine being quite smooth, (Pl. 29, fig. 4.) The teeth of the *Polyptychodon* may be distinguished at once from those of the *Mosasaurus* or *Pliosaurus* by the absence of the less convex, or almost flattened facet of the crown, which is divided by strong ridges from the remainder of the crown.

POLYPTYCHODON CONTINUUS, *Owen*. Plate 29, figs. 4, 5, 6.

'Odontography,' vol. ii, p. 19.

The first evidence of this species was a single tooth, which was discovered by W. H. BENSTED, Esq., of Rock Hall, near Maidstone, September 16th, 1834, in what is called the 'Trigonia-stratum' of Shanklin Sand, in the Kentish Rag Quarries near that town, this stratum being a member of the Lower Green-sand Formation. The tooth in question (Pl. 29, figs. 5 and 6,) has a crown upwards of three inches in length, and one inch four lines in diameter across its base. The compact dentine has been partially resolved by decomposition into a series of superimposed thin hollow cones, fig. 6, and the short and wide conical pulp-cavity is confined to the base, and beginning of the fang, which has been broken away. The cavity of the crown of the tooth in *Hypsodon* would seem to have been always much larger, as it is in many other predatory fishes in which the teeth are more rapidly shed and renewed than in the Crocodilian Reptiles. In the Collection of Henry Catt, Esq., of Brighton, is preserved the crown of a nearly equally fine specimen of the *Polyptychodon continuus,* from the Chalk of Sussex: this specimen is figured of the natural size in Pl. 29, fig. 4. A portion of the ridged enamel has scaled off, exposing the smooth surface of the dentine which it protected. The teeth of this species of *Polyptychodon* differ from those supposed to have belonged to *Poikilopleuron,* in the ridges of the crown being more numerous and close set, and in the transverse section being circular instead of elliptical.

GIGANTIC FOSSIL SAURIAN FROM THE LOWER GREEN-SAND AT HYTHE. *Crocodilia,* Plates 27, 28.

'Proceedings of the Geological Society of London, June 16th, 1841.'

I propose to describe these remarkable and highly interesting fossils under the present section, on account of the identity of the Formation in which they were discovered, with that of the tooth of *Polyptychodon continuus* above described, and because

no other teeth have as yet been found in the Cretaceous Series to which the fossils in question could be referred. These are at present, however, the chief grounds of the probability that such teeth and bones of a large Saurian, may have belonged to the same genus.

The bones about to be described, are unquestionably the remains of a Saurian of marine habits, but most probably of the Crocodilian order, as gigantic as the *Cetiosaurus* or *Polyptychodon*, but, in the absence of any associated parts yielding the dental and vertebral characters, not certainly referable to any known genus. They were discovered, in 1840, by H. B. Mackeson, Esq., of Hythe, in the Green-sand Quarries, near that town, and include portions of the coracoid, humerus, and ulna, of the iliac, ischial, and pubic bones, a large proportion of the shaft of a femur, parts of a tibia and fibula, and several metatarsal bones, four of which exhibit their proximal articular surfaces. The remains occupied a space in the quarry, of about fifteen feet by twelve, where it would seem that a proportion of the skeleton of this gigantic Saurian, including the pelvis with one hinder extremity, and a part of the fore-limb had been exposed. In consequence of the absence of vertebræ and teeth, the present observations will be limited to indicating the characters by which these remains differ from previously known extinct genera of Saurians. In the first place, as the femur and other long bones have no medullary cavities, but a central structure composed of coarse cancelli, it is evident that the animal of which they formed part was of marine habits, and did not belong to the *Dinosauria;* but the best-preserved bone being a femur, this circumstance, independently of the size and shape of the metatarsals, at once negatives the idea that these remains belonged to the Cetacean order, whilst the form and proportions of the metatarsals equally forbid their reference to any other Mammalian genus, or to the Reptilian order *Enaliosauria.* The cells of the cancellous tissue are about a line in diameter: the compact outer crust or wall of the bone is from four to five lines in thickness. In the recent state, the cells of the cancellous structure of the marine Saurian's bones were doubtless filled with a fluid oil, as in the similarly coarsely cancellous bones of the Cetaceans, and thus the specific gravity of the animal would be nearly accommodated to that of the fluid in which it principally, if not exclusively existed.

Femur.—The portions of this bone, Pl. 27, fig. 1, secured by Mr. Mackeson include about the two distal thirds, excepting the articular extremity; its length is 2 feet 4 inches; its circumference in the middle, or smallest part of the shaft, is 15 inches 6 lines, and at the broken distal end, 2 feet 5 inches. These dimensions prove that the animal was equal to the most gigantic described *Iguanodon.** If the supposition of the proportion of the femur which has been preserved be right, this bone differs from that of the *Iguanodon,* not only in the want of a medullary cavity,

* The length of the largest femur yet obtained of this Saurian is 4 feet 6 inches, its smaller circumference 1 foot 10 inches.

but also in the absence of the compressed process which projects from the inner side of the middle of the shaft. The bone also expands more gradually than in the femur of the *Iguanodon*, and the posterior part of the condyles must have been wider apart in consequence of the posterior inter-condyloid longitudinal excavation being longer and wider. The middle part of the shaft of the femur is subcompressed, with a nearly quadrilateral contour of the transverse section, the line bounding the outer side being less convex and longer than that which circumscribes the inner side of the bone: the anterior surface is flatter than the posterior one. The anterior and outer surfaces meet at a more marked angle than do any of the others; the angle being formed by an obtuse ridge. The concavity of the posterior surface begins about 6 inches above the broken distal end of the present fragment, and gradually increases in both width and depth as it descends. The width of the inter-condyloid groove at the fractured distal end is 5 inches 4 lines. The same admeasurement in the largest *Iguanodon's* femur gives 2 inches. The convex ridge leading to the inner condyle is more prominent than the outer one; and on the tibial side of the inner ridge there is a second slight concavity. On the anterior surface of the distal end of the femur there is a broad shallow depression of the surface, corresponding to the deeper one behind, and there is not the narrow and deep groove which characterises the corresponding part of the femur of the *Iguanodon*. The texture of the distal end of the bone presents the same coarse cancelli as occupy the middle of the upper part of the shaft, but with a thinning of the outer laminated compact crust. The following are admeasurements of the bone not given in the above description:—

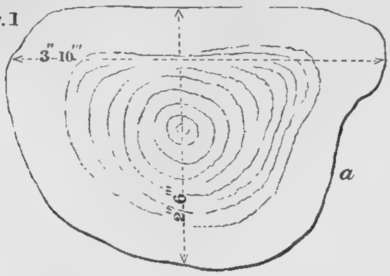
	Inches.	Lines.
Transverse diameter of the middle of shaft	5	6
Antero-posterior or lesser diameter of ditto	3	9
Greater diameter of the distal end	12	0
Smaller diameter of ditto at middle of the inter-condyloid groove	5	0

Tibia and Fibula.—The portion of a tibia, Pl. 28, fig. 1, T, which has been preserved, is compressed near its head, and the side next to the fibula is slightly concave. The longest transverse diameter is 8 inches 9 lines, and the two other transverse diameters at right angles to the preceding give respectively 3 inches 3 lines, and 2 inches 6 lines. The bone soon assumes a thicker form, its circumference at about one third from its proximal end being 16 inches 6 lines. The compact laminated outer wall of the bone is 4 lines thick. The cancelli occupying the central portion of the bone are arranged in a succession of layers around a point nearest the narrower end of the transverse section. Lower down the tibia again becomes compressed, and towards the distal end the transverse section exhibits the form of a plate bent towards the fibula, and its narrowest transverse diameter is $2\frac{1}{2}$ inches.

The portion of the fibula, Pl. 28, fig. 1, F, is $11\frac{1}{2}$ inches long. In the middle it is flat on one side, slightly concave on another, and convex on the two remaining sides.

An outline of a section of this part is given at Fig 1. It presents the same cancellous structure as the tibia, but the concentric arrangement of the layers of cells is more exact. Towards the opposite end of the bone the concave side becomes first flat, and is then produced into a convex wall, terminating one end of a transverse section of a compressed and bent thick plate of bone. The long diameter of this section is 6 inches 6 lines at the end of the fragment; 4 inches from that end it measures 5 inches 6 lines: the shorter diameter of the compressed bone at the same part is 1 inch 10 lines; an outline of the transverse section of this part is given in Fig. 2. Of several long and strong bones, which from their form and relative size represent metatarsals, there are considerable portions of four, detached, with their proximal articular surfaces preserved; a fifth, wanting the articular extremities; and two others longitudinally split and imbedded in a mass of the Green-sand matrix; these latter exhibit the characteristic inequality of length of the Crocodilian metatarsals, and are probably the innermost and second metatarsals of our present gigantic Saurian.

Fig. 1



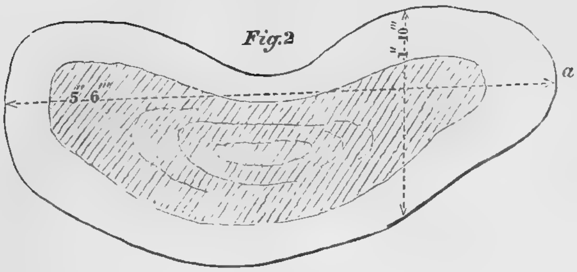
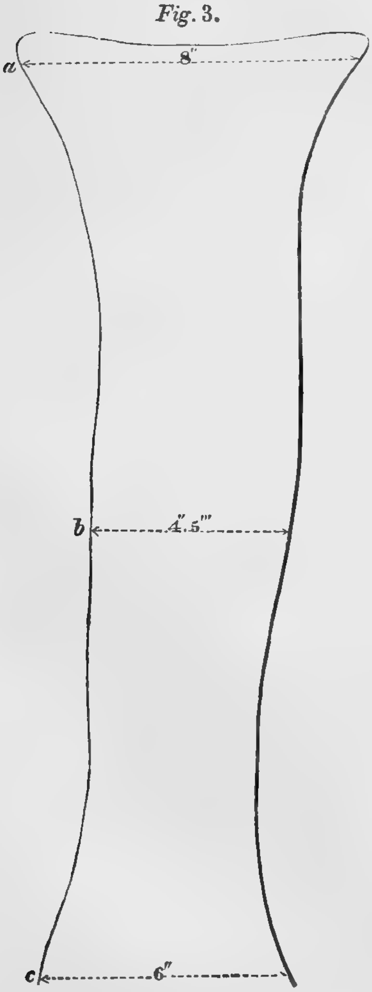


Fig. 3.



Outline of an imbedded metatarsal of the *Polyptychodon*. Scal 2½ inches to a foot.

The innermost and smallest measures one foot in length; the adjoining metatarsal two feet. Their position in the rock shows that the part of the skeleton had been separated through decomposition before they were permanently imbedded, the proximal articular extremities being 3 inches apart, but on the same transverse line.

The outline of the larger of these imbedded metatarsals is subjoined at fig. 3; its transverse diameter at *a*, is 8 inches, at *b*, 4 inches 5 lines, and at *c*, 6 inches.

The smaller metatarsal is more contracted at the shaft which presents a triedral contour: the diameter of its greater end is 5 inches; that of the narrow part of the shaft is 1 inch 11 lines; its compact outer crust is between one and two lines thick; all the rest of the substance presents a cellular texture, the cells having a diameter of one half to two thirds of a line.

Fig. 4.

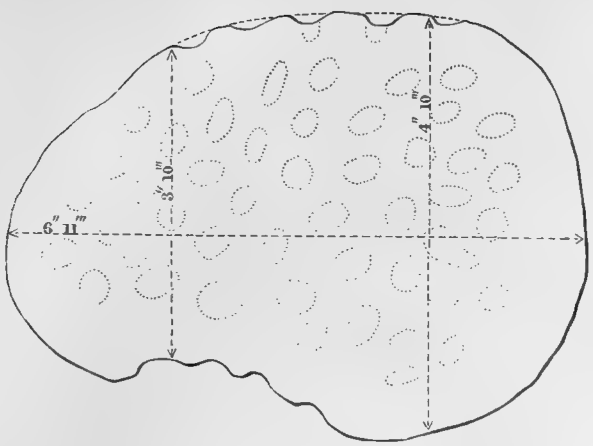
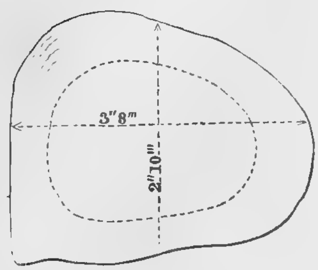


Fig. 5.



Proximal end and section of shaft of a metatarsal of *Polyptychodon* ?

Fig. 6.

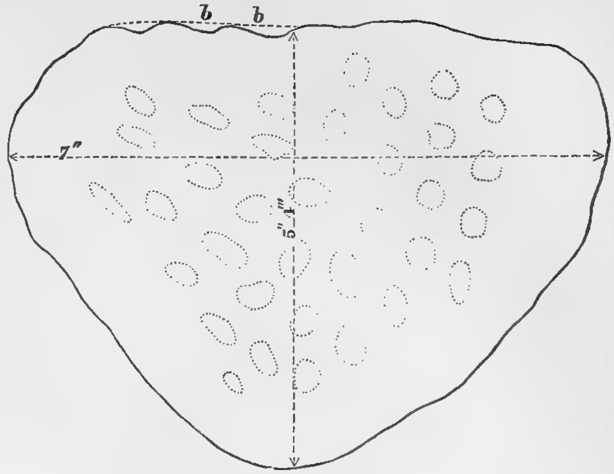
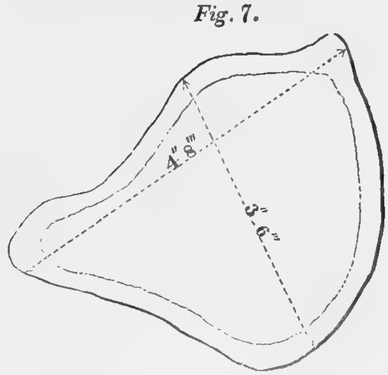


Fig. 7.



Proximal end and section of shaft of a metatarsal of *Polyptychodon* ?

Of the detached metatarsals I subjoin outline sketches of the articular end, and the transverse section of the shaft for facilitating the comprehension of their form and their comparison with other remains. The chief of these is the proximal portion of a metatarsal bone 15 inches, 6 lines in length. Figure 4 is the contour of the articular end, which is slightly convex at the smaller side, nearly flat at the wider one, and with a very irregular superficies, being pitted all over with depressions admitting the end of the little finger, these depressions at some parts of the circumference of the articular end being continued into as broad grooves, which soon subside to the level of the surface of the shaft. Figure 5 is the outline of the fractured end, nine inches from the articular end of the same bone: the angle indicates a ridge which runs obliquely down the bone towards the middle of the surface, and subsides near the broken end, fifteen inches down the shaft. The dotted line indicates the thickness of the laminated wall, which gradually becomes less compact, and encloses a coarse cancellous structure. The outer surface of the bone is smooth.

Figure 6 gives the contour of the articular end of a proximal portion of a metatarsal bone 11 inches long. The articular surface is pitted with cavities, as in fig. 4, the size of the same, as if for a coarse ligamentous articulation: the cavities are continued into grooves at *b b*. Figure 7 gives the contour of the broken surface, six inches

below the proximal end: the whole thickness of the bone, within the compact outer wall, being occupied by a coarse cancellous structure.

Fig. 8.

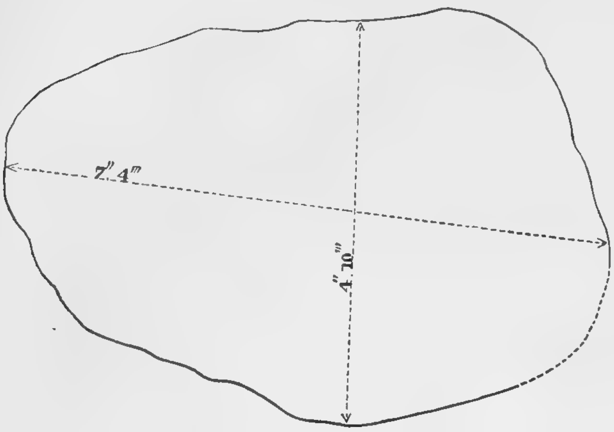


Fig. 10.

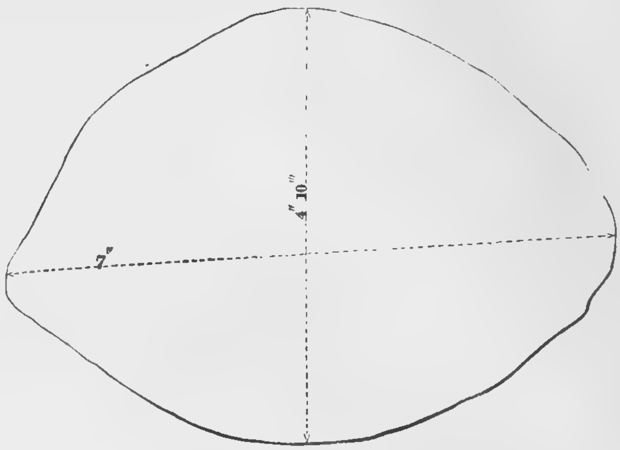


Fig. 9.

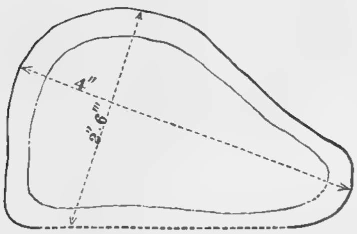
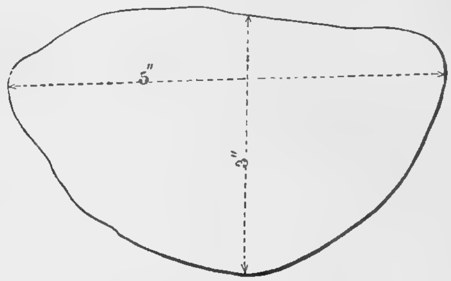


Fig. 11.



Proximal end and section of shaft of a metatarsal bone of *Polyptychodon*.

Of a fragment, 12 inches long, of the proximal portion of a metatarsal bone, figure 8 gives the contour of the articular end; and fig. 9 of the fractured end of the shaft; the dotted outline indicates where the outer crust of the wall prevented an exact figure of the contour being made; but the shaft of the bone seemed to have been flat on that side.

A fourth fragment of a long bone measured 10 inches in length. Figure 10 gives the contour of the proximal articular end of this bone (the outer wall having scaled off). Figure 11 is the contour of the fractured end of the shaft, 5 inches beyond the articular end. It is occupied by a coarse cancellous structure throughout.

There remain to be noticed some less perfect fragments of huge flat bones imbedded, or indicated by their impressions, in masses of the Green-sand Rock. In three of these I recognise the ilia, ischia, and pubes: they are broader than in the Crocodiles, but would be conformable to the Crocodilian type, if the cartilaginous parts of some of those bones in the recent species were ossified: by this greater extent of ossification of the large fossils in question, the pubis and ischium approach somewhat to the Plesiosaurian type. The ilia are imbedded in the same block of stone: they are flat,

nearly straight, and become gradually wider and thicker towards the end attached to the sacrum: of these bones a portion 25 inches long is preserved of the one, (Pl. 27, fig. 6,) and 20 inches of the other: the broadest end of the longer portion measures across 10 inches. In a second block, the mesial extremities of the pubis and ischium are preserved. The exposed surface of the pubis is principally convex, but becomes concave towards the opposite or median margin: it measures across at its broadest part 13 inches; the length of the fragment preserved is 17 inches. The diameter of the corresponding expanded extremity of the ischium is 9 inches: its expanded extremity is obliquely truncated; that of the pubis is rounded. In another block the expanded extremity of the opposite pubis is preserved; it measures 14 inches across, and is 22 inches in length.

In a third large mass of rock, the fragment of an enormous, apparently sub-quadrilateral flat bone, is exhibited, which most probably belongs to the pectoral arch, and, in that case, must be the coracoid bone, Pl. 27, fig. 5, P. The length of this fragment is two feet, its greatest breadth 17 inches: its thickness varies from 3 to 5 inches. On one side there is a slight submedian ridge, from which the surface slopes away with a gentle concavity.

The breadth of this bone indicates the great development of the muscles destined for the movement of the fore-leg, whence it may be inferred that the anterior extremities were more powerfully and habitually used in progressive motion than in the Crocodiles. In the existing species of this family, the anterior extremities are used chiefly for the support and movements of the body on land; they are applied to the sides of the chest when the animal swims, which is chiefly effected by the actions of the strong and long vertically compressed tail. The lateral movements of the fore-legs being much restricted, the coracoid bone and the muscles arising from it are comparatively slender. In the Enaliosauria, where the fore-legs are converted into paddles for swimming, the coracoids are vastly expanded, both for the increased strength of the shoulder-joint and the increased surface for the attachment of the muscles, which effect the lateral movements and the stroke of the paddle-shaped limb upon the water. We may infer, therefore, that the anterior extremities of the present gigantic Crocodilian were, by some webbed modification of the hand, better adapted, and more energetically used for swimming than in the existing Crocodilians.

The shaft of a long bone somewhat similar to, but shorter and more slender than the femur, and crushed, is preserved with that of a smaller bone, tapering more gradually to one end, in the same block of stone: these are figured in Pl. 28, fig. 2; the larger bone is probably the humerus, H, the smaller one the ulna, U.

Other less intelligible fragments of the long bones of the same great Saurian are represented in Pl. 27, figs. 2, 3, and 4; and in Pl. 28, figs. 2 and 4. Fig. 3 probably shows two of the metacarpals in the same block of stone.

The principal parts above described are preserved in the British Museum, to

which Institution they were liberally presented by their discoverer H. B. Mackeson, Esq. They were mutilated in the attempt to disencumber them of the massive blocks of the matrix in which they were imbedded, and are less characteristic than when I took the foregoing description and sketches of them on the spot where they were found.

It has been shown that the texture of the femur, tibia, fibula, and the other long bones, is conclusive against the identity of the Saurian of the Hythe Lower Green-sand with the great ambulatory Dinosaurian reptiles, viz., Iguanodon and Megalosaurus, the former discovered in the Lower Green-sand at Maidstone, and both species also in the Wealden and Oolite Formations; there then remains to be considered its relationship with the Enaliosaurians, the Crocodilians, the Mosasaur, and Poikilopleuron.

The length, thickness, and indication of condyles in the femur, and the length, thickness, and angular form of the metatarsals, place the Plesiosaurs, and, *à fortiori*, the Ichthyosaurs, out of the pale of comparison.

The superior expanse of the pubis, and the broad coracoid (?) with the form of the femur, and the gigantic proportions of all the bones, forbid a reference of the Saurian in question to any subgenera, recent or extinct, of the Crocodilian Reptiles, of which the bones of the extremities were previously known.

If it were true that the *Mosasaurus* had locomotive extremities in the form of flattened paddles, like the *Plesiosaurus*, the identity of our present Reptile with the Maëstricht species would be at once disproved, by the unequivocal remains of the metatarsal bones, which indicate a form of foot, corresponding, as far as the skeleton is concerned, with that of the Crocodile: and if, as is most probable, the metatarsals of the Lacertian type from the Green-sand of New Jersey appertain to a *Mosasaurus*, the metatarsals from the Green-sand at Hythe differ from them in size, shape, and the absence of any medullary cavity.

With regard to the Crocodilians, the extinct genus which most closely agrees with the characters of the bones of the Hythe Saurian is that which I have named *Cetiosaurus*, the vertebræ of which have been found in the Wealden and Oolite formations, and the long bones of which are devoid of a medullary cavity. Unfortunately no vertebra referable to *Cetiosaurus* has yet been discovered in the Cretaceous deposits. It is possible that the teeth on which the genus *Polyptychodon* has been founded may belong to *Cetiosaurus;* but hitherto such teeth have not been discovered in the strata where the remains of *Cetiosaurus* are common.

The gigantic Saurian discovered by M. Deslongchamps, in the Oolite at Caen, and which he has named *Poikilopleuron Bucklandii*, yields for comparison with the Hythe Saurian the femur, fragments of the tibia, fibula, and metatarsal bones.

In the form of the condyles of the femur, and their posterior intervening channel, the Hythe Saurian resembles the Poikilopleuron more than it does the Iguanodon; but the large medullary cavity in the femur of the Poikilopleuron distinguishes it as

much as it does that of the Iguanodon from the Hythe Saurian. The medullary canal is described as being very great in the tibia of the Poikilopleuron.*

The absence of vertebræ and teeth in the Hythe specimen prevents the establishment of a comparison of these instructive parts of the skeleton of the two extinct Saurians, and the question of the dental characters of the Poikilopleuron remains in the same doubtful state as it is left by M. Deslongchamps, who describes and figures a detached large Crocodilian tooth from the Oolite near the village of Allemagne, as corresponding in size with the remains of the Poikilopleuron.†

M. Deslongchamps conceives it may be useful to make known these teeth at the same time with his Poikilopleuron, leaving to subsequent discoveries the determination of the truth or otherwise of the approximation. For the same motive I have prefixed to my account of the Hythe Saurian a description of the teeth of a gigantic, and hitherto unknown Saurian from the Green-sand at Maidstone, and shall append to it an account of similar teeth from the Chalk Formation in Sussex, Kent, and Cambridgeshire.

Since the bones of the extremities of Mr. Mackeson's large reptile from the Green-sand afford sufficient evidence of their distinctness from the tallying parts of any previously described Saurian genus, and since we have evidence as satisfactory of an equally gigantic Saurian genus from the teeth which occur in the same Formation, it may be allowable, for the purposes of the present record, to regard both the bones and the teeth as parts of the same animal. Until, therefore, further evidence is obtained, showing the Hythe skeleton to have been furnished with differently-formed teeth, or the teeth from the Maidstone Green-sand to have been associated with a differently constructed skeleton, I shall apply to the Hythe fossil the name of *Polyptychodon*, under which the genus of gigantic Saurian, hitherto known only in the Green-sand and Chalk strata, was first indicated.

POLYPTYCHODON INTERRUPTUS, *Owen*. Lacertia, Plate 2, figs. 16, 17. Pl. 8, fig. 3. Crocodilia, Plates 26 and 29, figs. 1 and 2.

'Odontography,' vol. ii, p. 19, pl. 72, fig. 4; and in Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Deposits of Sussex,' p. 378.

The majority of the specimens of the teeth of this species have been found in the middle and lower Chalk or Chalk-marl: one large tooth of this species has been

* "Le canal medullaire était fort grand; l'epaisseur du tissu compact, en *d*, est d'environ $0^{m.}$ 015." (Deslongchamps, 'Sur le Poikilopleuron,' 4to, p. 55.)

"Dans ce tiers inférieure, le femur est un peu plus étendu transversalement que d'avant en arrière." (Deslongchamps, loc. cit.)

† "On a trouvé, à diverses epoques, dans les carrières du Village d'Allemagne de grandes dents, toujours isolées, offrant tous les caracterès de celles des Crocodiles. J'en figure une, pl. vi, (de grandeur

discovered by the Rev. Peter Brodie, M.A. F.G.S., in the upper Green-sand at Barnwell, near Cambridge, and a few other specimens have been obtained by James Carter, Esq. from the Green-sand of another locality, near Cambridge.

The fine examples of teeth figured in Pl. 26 (with the exception of fig. 8) were discovered in 1847 by Mr. POTTER, of Lewes, in the lower bed of Chalk-marl, just above the Green-sand, in the vicinity of that town. They formed part of as many as from twenty to thirty teeth of nearly the same size which were scattered at no great distance from each other. No part of the jaw-bones could be detected; and as the teeth are fully formed, and some of them retain their long fangs, it may be inferred that they were originally implanted freely, like the teeth of the Crocodile, in loose sockets, and have dropped out as easily, after the decomposition of the gums and other soft parts. The crown is about two sevenths the length of the entire tooth, and its enamelled striated coat terminates by an abrupt and well-defined border; the fang continues to expand to about its middle part, whence it gradually contracts to an obtuse end, which is perforated by the entry to the pulp-cavity. The general shape of the crown agrees with that of the *Polyptychodon continuus;* the difference is shown by the greater proportion of the ridges which stop short of the apex of the crown, especially on the convex side of the tooth. In using the term convex or concave as applied to the crown, allusion is made to the slight bend of crown in the direction of its axis. Around the entire basal part of the crown the ridges are close together: their interspaces are only the clefts that separate them. On the concave side of the tooth a large proportion of the ridges extend nearly to the apex, as is shown in Pl. 26, fig. 1; but on the convex side a greater number extend only one third or two thirds towards the apex, these shorter ridges alternating with the longer ones, between which, therefore, at the apical part of the tooth, there are intervals of flat tracts of enamel. The apex of the tooth is rather obtuse. On one side of the crown there is a long ridge, towards which contiguous shorter ones have a convergent inclination. The long fang of the tooth is covered by a layer of smooth cement. The dentine is compact, and corresponds in microscopic structure with that of the crocodile's teeth. In the fractured specimens of the teeth from Lewes, the dentine had become resolved into superimposed conical layers, as in the larger tooth from the Green-sand of Maidstone: this effect of long interment is represented in figs. 1, 3, 5, and 7, of Pl. 26. There is no trace of the absorbent action excited by pressure of a successional tooth in any of these specimens of teeth.

Although the detached state of the above-described teeth with well-developed fangs would have suggested and sustained the inference that they had been implanted like

naturelle, fig. 8, reduite au quart, fig. 9.) Elles ont intériurement une cavité conique; leur surface couverte d'email jusqu'à une certain distance de leur base, est ornée des stries en relief, longitudinales, de longeur inégale, dont deux seulement, situées aux extremités du même diamètre, arrivent jusqu'à la pointe." (p. 80.)

the teeth of the Crocodile, direct evidence to that effect had not been obtained at the time of the publication of my 'Report on British Fossil Reptiles;' and it has been objected that the mode of fixation of the teeth of the Polyptychodon might have been the same as in the Mosasaurus, and that those teeth might belong to a second extinct genus of gigantic Sea-lizards. The specimen, however, which is represented of the natural size in Pl. 8, fig. 3, inclines the balance in favour of the Crocodilian affinities of the Polyptychodon, by proving that its teeth were implanted in distinct sockets, and not anchylosed to the summits of processes of the jaw, as in *Mosasaurus* and *Leiodon*. In the figure cited, taken from an unique specimen of part of the lower jaw of the *Polyptychodon interruptus* discovered in the lower chalk-deposits of Kent, and now in the collection of Mrs. Smith, of Tonbridge Wells, the letter *b* shows the smooth cement-covered cylindrical base, and *c* the enamelled conical crown; *s* is an adjoining vacant alveolus, from which a tooth similar to that in place has slipped out, like the teeth from the Lewes Chalk-marl. The crown of the tooth in place is rather longer in proportion than in most of the detached teeth from Lewes; and it may, therefore, indicate a certain inequality in the length of the crowns of the teeth in the same jaw, as in the Crocodiles, and it may have answered to the tooth which is sometimes called, on account of its greater length, the "canine tooth" in the Crocodile. The socket anterior to the one with the completed tooth contains the germ of a young tooth, and shows that the teeth succeeded each other from the same sockets as in the modern Crocodiles.

The crown of a much larger tooth of the *Polyptychodon interruptus*, which is figured in Pl. 2, figs. 16 and 17, was found near Valmer, during the cutting of the Lewes railway, and is now in the museum of Henry Catt, Esq., of Brighton. It shows well that alternate and interrupted character of the longitudinal ridges of the enamelled surface which distinguishes the present species; but the ridges have been more worn down, especially towards the apex, in Mr. Catt's specimen, than in the one originally figured in my 'Odontography.'* The body of the crown consists of a hard compact dentine, partly resolved in the specimen by incipient decomposition into superimposed hollow cones, like the similarly-sized tooth of the *Polyptychodon continuus* from Mr. Bensted's Green-sand "Iguanodon" quarry at Maidstone.† The cylindrical base of the tooth is excavated by a wide conical pulp-cavity with an obtuse summit, into which a small central process projects from the base of the crown (fig. 17). The enamel is very thin at the base of the crown.

Figure 8 in 'Crocodilia,' Pl. 26, is the crown and part of the base of a still larger tooth of apparently the same species of *Polyptychodon*, obtained by Mr. Catt in October 1850, from the grand and picturesque chalk-pit, or rather chalk-cliff, at Houghton, near Arundel.

* Odontography, pl. lxxii, figs. 4, 4'.

† Ib. fig. 3, and 'Report on British Fossil Reptiles,' p. 156.

One or two of the long ridges of this tooth are more than usually prominent, and most of the shorter ones are fainter than usual; but I cannot regard those differences in any other light than as individual varieties. The pulp-cavity at the base of the tooth, filled up in the specimen by the white chalk, appears to have been unusually large, as if the specimen had been in an incompletely developed state. If this were the case, it must have come from a very large specimen of the present species of extinct reptile.

To such a specimen must have belonged the anterior end of the left ramus of the lower jaw, ('Crocodilia,' Pl. 31,) discovered in the Burham Chalk-pit, in Kent, and now in the choice and instructive Collection of J. Toulmin Smith, Esq. The fragment is upwards of a foot in length, but contains only three alveoli, and corresponded, probably, to the premaxillary part of the upper jaw of the same animal. The first socket, *s* 1, is nearly three inches from the fractured end of the jaw, and two inches from the larger socket, *s* 2, behind it; the third socket, *s* 3, is closer to the second. These are filled up by the chalk, the teeth having fallen out. The outer surface of the jaw is convex and prominent; a solid mass of the bone extends horizontally inwards from the anterior socket, to form the symphysis, which seems to have been ossified, with the opposite ramus. The substance of the bone has the same coarse cancellous tissue as that of the portion of the smaller jaw of *Polyptychodon*, ('Lacertilia,' Pl. 8, fig. 3); and, as it shows a similar inequality in the intervals of the alveoli, it may be concluded to belong to the same genus, if not species, of extinct Crocodilian reptile. The present fragment (Pl. 31) indicates an individual as large as the great *Mosasaurus*, the skull of which was discovered in the Maestricht Chalk.

Fine specimens of crowns of the teeth of both species of *Polyptychodon*, have been obtained by James Carter, Esq., M.R.C.S., of Cambridge, from the Upper Green-sand near that town, and also at Horn-sea, in the same county. These specimens present a darker colour than those of the chalk, by reason of the modification of their matrix. The ridges are remarkably well defined on the enamel; the dentine presents the same well-marked division into layers, cone within cone, as in the Chalk specimens, and that from the Shanklin sand near Maidstone. The crown of one of the specimens of the *Polyptychodon interruptus*, from the Cambridge Green-sand, equals in size that of the *Polyptychodon continuus*, discovered by Mr. Bensted in his quarry near Maidstone.

CHAPTER IV.

ORDER—*ENALIOSAURIA.*

Genus.—PLESIOSAURUS, *Conybeare.*

Besides the teeth which, according to their form and structure, were referable to the different genera and species of *Reptilia* above described,—viz. to *Raphiosaurus,* (Pl. 9, fig. 2;) to *Coniosaurus,* (Pl. 2, fig. 19*a*;) to *Mosasaurus,* (ib., fig. 1;) to *Leiodon,* (Pl. 10, fig. 1;) and to *Polyptychodon,* ('Crocodilia,' Pl. 26 and Pl. 29,)—we now, for the first time, in our progressive researches, descending through the strata which indicate the changes which the part of the earth's surface, forming England, has undergone, meet with teeth of different and peculiar type, remarkable, viz., for their length and slenderness, and with a circular transverse section, not subcompressed or with opposite trenchant margins, as in the Gavials of the Tertiary deposits. The tooth represented of the natural size in Pl. 2, fig. 8, is a good example of one of those of the form in question. Its enamelled crown, if entire, would exceed an inch and a half in length, yet it is but half an inch in diameter at its base; the crown is slightly curved and tapers gradually to a point; the enamel presents some slender but well-defined longitudinal ridges of different lengths, and none of them extending to the apex. The fang or root is cylindrical, smooth, and covered by a thin cement. The tooth above described was obtained from the Scaddlescombe Chalk-pit, near Lewes, Sussex.

A similar specimen, rather more fractured, Pl. 2, fig. 9, was found in a Chalk-pit at Southeram, Sussex.

A smaller tooth, (Pl. 2, fig. 13,) of the same type, but with more numerous longitudinal ridges, seems to indicate a different species. This specimen was also found at Southeram.

If satisfactory and abundant evidence of the nature of the extinct reptile to which the above-described teeth belong had not been obtained from Secondary Formations of a more ancient date than the cretaceous ones, the Comparative Anatomist would have inferred, and correctly, the generic distinction of the Reptile to which they belonged; but he could have had no suspicion of the truly extraordinary nature of the animal, the entire race of which, after flourishing under a variety of specific forms from the epochs of the Muschelkalk and Lias, finally perished at the time of the deposition of the Chalk.

The anatomical description of the *Plesiosaurus,* discovered and restored by CONYBEARE and DE LA BECHE, will be reserved for the Monograph descriptive of the fossil Reptiles of the formations in which its remains are most abun-

dant; and I shall here limit myself to quoting the brief but graphic definition of it which Dr. Buckland has given in his interesting and instructive 'Bridgewater Treatise:'—"To the head of a Lizard it united the teeth of a Crocodile; a neck of enormous length, resembling the body of a Serpent; a trunk and tail having the proportions of an ordinary quadruped; the ribs of a Chameleon; and the paddles of a Whale. Such are the strange combinations of form and structure in the Plesiosaurus," (p. 102.) I may add, that of all existing Reptiles the Chelonians make the nearest approach to the present remarkable extinct genus in the length and flexibility of the neck, in the size of the true body of the atlas, which resumes its normal relations with the neural arch of that vertebra in *Chelys* and *Chelodina*, as in *Plesiosaurus;* in the natatory form of the extremities as exemplified in the paddles of the Turtle, which besides being four in number, come much nearer those of the *Plesiosaurus* in structure than the paddles of the Whale do, and in the great expanse of the ischium and pubis: whilst the Plesiosaurs exhibit, next to the Turtles, the greatest development of the abdominal ribs (hæmapophyses and their spines), which form a kind of interwoven flexible "plastron" beneath the abdomen.

PLESIOSAURUS BERNARDI, *Owen*. 'Enaliosauria,' Plate 26.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' p. 396.

In my 'Report on British Fossil Reptiles,' one species of *Plesiosaurus,* viz. *Plesiosaurus pachyomus*, was defined from remains discovered in the green-sand division of the Cretaceous series;* and the existence of the genus *Plesiosaurus*, at the period of the deposition of the latest member of that series, was inferred from the discovery of the femur of a large species in the chalk which forms the well-known "Shakespeare's Cliff" near Dover.†

This indication has been since confirmed by the discovery not only of the teeth above described, but of vertebræ of the *Plesiosaurus* in the same formation; and the cervical vertebra figured in Pl. 26, which was obtained from the Upper Chalk at Houghton, near Arundel, Sussex, indicates a species allied to the *Plesiosaurus pachyomus* from the green-sand of Cambridge.

The following are the dimensions of the vertebra from Houghton, and of the most perfect of those of the above-cited species from the green-sand.

	Pl. pachyomus.		*Pl. Bernardi.*	
	Inches.	Lines.	Inches.	Lines.
Antero-posterior diameter of centrum	2	0	1	9
Transverse diameter	2	9	3	0
Vertical diameter	2	6	2	0

The breadth of the centrum is proportionally greater in the vertebra from the chalk, which further differs from that from the green-sand in the lower position, and

* Report on British Fossil Reptiles, Trans. Brit. Association (1839), p. 74.

† Ibid., p. 193. This specimen was kindly transmitted to me by J. Wickham Flower, Esq.

the anchylosis of the pleurapophyses, *pl* (hatchet-bones or cervical ribs); which, if they presented the characteristic expansion of their extremities, must have supported the hatched-shaped head on an unusually long body or pedicle. The articular surfaces of the centrum are more concave than in most *Plesiosauri*, and deepen to a central pit, in which they resemble those of the *Plesiosaurus pachyomus;* but the circumference of the articular surface is more extensively rounded or bevelled off, so that its convexity is seen, as at *c a*, *c p*, upon a side view of the vertebra, fig. 3, Pl. 26.

Both neurapophyses, fig. 3 (*n*), and pleurapophyses (*pl*) are anchylosed to the centrum. The neurapophyses coalesce together, and send almost vertically upwards a spinous process, which exceeds in length the whole vertical diameter of the vertebra below it, and is more than twice its own antero-posterior diameter; it is compressed and gradually decreases in thickness as it rises; it presents a rough shallow tract along its fore part (fig. 1), and a wider, deeper, and smoother excavation behind (fig. 2). Two small zygapophyses are developed from both the fore-part (*z*) and back part (*z'*) of the neural arch. The pleurapophyses (*pl*) are long, sub-depressed, slightly expanded as they extend downward, outwards, and backwards; but the fractured ends do not show how far they have extended forwards and backwards into a hatchet-shaped extremity. They have coalesced with the lower part of the sides of the centrum, an extent more than their own vertical diameter intervening between them and the base of the anchylosed neurapophyses. The articulated cervical ribs in the *Pl. pachyomus* (Pl. 28) have not quite so low a position on the centrum, and are thicker vertically.

The under part of the centrum presents two deep pits from which the vascular canals ascend, divided by a moderately thick, convex, longitudinal bar (fig. 4). The non-articular surface of the centrum is smooth, and the sides of the centrum are slightly concave.

A very interesting and well-marked species of the singular genus *Plesiosaurus*, in addition to those from the older secondary strata, is thus indicated by the present unusually perfect fossil vertebra. As it was discovered on one of the estates of his Grace the Duke of Norfolk, I avail myself of the opportunity of fulfilling a wish of my lamented friend Mr. Dixon, and of gratifying my own, by dedicating this new species to the memory of LORD BERNARD HOWARD, a young nobleman of great promise and most amiable disposition, and who had given much attention to the science of geology: he died suddenly in Egypt at the early age of twenty-one years, whilst pursuing his travels in order to acquire a knowledge of the antiquities, the arts, and policy of distant countries.

PLESIOSAURUS CONSTRICTUS, *Owen*. 'Lacertians,' Plate 2, figs. 6 and 7.

Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' p. 398.

The species of *Plesiosaurus* from the Chalk-pit at Steyning, Sussex, indicated by the centrum of a middle cervical vertebra, which is figured in the above-cited Plate, figs. 6

and 7, differs from that of the *Plesiosaurus Bernardi*, ('Enaliosauria,' Pl. 26,) in its great length, as compared with the height and breadth of the articular surfaces of the centrum, and in the small size of the costal articulation (*pl*), the pleurapophyses having been unanchylosed to the centrum; it also differs from all the species of Plesiosaur hitherto defined in the degree of lateral constriction of the centrum between those surfaces, if this be natural. The free or non-articular surface of the centrum is rugose, showing the coarsely fibrous texture of the bone. The under surface (fig. 6) is slightly concave, both transversely and longitudinally, is subquadrate and oblong, with two approximated vascular orifices at its centre, separated by a slight rising, which is not developed into a ridge. The small costal surfaces (*pl*) are elliptic, situated at the middle of the ridge dividing the under from the lateral surfaces of the centrum, twice their own vertical diameter below the neurapophysial surfaces, and equidistant from the two ends of the centrum. The articular surfaces here are convex at their circumference, slightly concave in the rest of their extent, with a feeble longitudinal rising at the centre, interrupted by a transverse linear groove. The neurapophyses terminated below in a very open angle. The vertebra appears to have been subject to pressure, and is slightly distorted; but it is difficult to conceive how this could have operated so partially as to have produced the compressed character of the middle of the centrum and have left the two articular ends of their natural form.

The following are its principal dimensions.

	Inches.	Lines.
Antero-posterior diameter of centrum	2	4
Transverse diameter of articular surface of ditto . . .	2	2
Vertical diameter of ditto	1	$7\frac{1}{2}$
Distance between the neurapophysial and costal pits . .	1	0
Transverse diameter of middle of centrum above the costal pits	1	7

It is most probable that the teeth of the *Plesiosaurus*, Pl. 2, figs. 8 and 9, belong, by reason of their size, to the *Plesiosaurus Bernardi.*

A much-fractured tooth, (Pl. 2, fig. 15,) as thick as those of figs. 8 and 9, but diminishing more rapidly to the apex, shows similar unequal but more numerous ridges all round the enamelled surface; its crown is composed of the same kind of hard dentine as in the Crocodiles and Plesiosaurs, with a moderately thick covering of enamel. The tooth may be a variety of the Plesiosaurian type, or it may have belonged to a Steneosauroid Crocodilian. It was obtained from the same chalk-pit, at Houghton, near Arundel, as the vertebra of the *Plesiosaurus Bernardi.*

The teeth, 'Enaliosauria,' Pl. 28, figs. 7 and 8, present more slender proportions, and so far, are more strictly Plesiosauroid. The fang is round, smooth, and deeply excavated by the pulp-cavity, which is indicated by the dotted line at *p;* the enamelled crown supports numerous fine longitudinal ridges: it is rather more compressed at its fractured

end than in the typical Plesiosaurian teeth. These specimens were found in the lowest bed of the Lower Green-sand beneath Shanklin Chine, Isle of Wight; I am indebted for the drawings of them to John Edward Lee, Esq., of the Priory, Caerleon, Monmouthshire.

VERTEBRA OF A PLESIOSAURUS. 'Enaliosauria,' Plate 27.

The subject of the above-cited Plate is a mutilated vertebra, there figured of the natural size, which was obtained from the Chalk-pit at Burham, in Kent, and is now in the Collection of Mrs. Smith, of Tunbridge Wells.

The centrum, slightly concave at both ends, with a large vertically oval depression, fig. 3, *pl*, for a rib on each side, and with a pair of vascular foramina on its under surface, fig. 2, *c, c*, shows the characters of the genus *Plesiosaurus*, with which the structure of the neural arch is conformable.

The following are the chief dimensions of this vertebra.

	Inches.	Lines.
Antero-posterior diameter of the centrum	2	2
Transverse diameter of its articular end	3	0
Vertical diameter of ditto	3	0

This vertebra differs from that of the *Plesiosaurus Bernardi*, not only in the proportions indicated by the dimensions above given, but likewise by the non-anchylosis of the rib, and by the shape and position of the surface for its attachment to the centrum: and if the value of these differences were to be questioned on the ground that the present vertebra might be one nearer the back than the vertebra figured in Pl. 26, at which part of the spine the cervical ribs increase in size, have their junction raised nearer to the neural arch, and retain longer their individuality in the species in which they become anchylosed in the more advanced vertebræ, there would still remain the following differences:—the vascular foramina on the under surface are not situated in such deep and well-defined pits; the concave terminal articular surfaces have not the central depression: the sides of the centrum are not bevelled off at the border of these articular surfaces, but are divided from them at a right angle by a well-defined margin. My present experience of the constancy of such secondary characters in the cervical vertebræ of the same species of *Plesiosaurus*, leads me to conclude that the vertebra figured in Pl. 27 is of a distinct species of *Plesiosaurus* from that figured in Pl. 26, a conclusion to which we are also led by the consideration that the vertebral bodies usually gain in breadth as they approach the back, whilst the vertebra, (Pl. 26,) with a lower placed rib, is relatively broader than the present one. From the *Plesiosaurus pachyomus*, from the Green-sand of Reach, near Cambridge,* the present specimen differs in the form of its costal surface, which

* Report on British Fossil Reptiles, 1839, p. 74.

is vertically instead of being transversely elliptical: it is still more obviously distinct from the *Plesiosaurus constrictus*, from the Chalk of Steyning, in Sussex. Although the sutures connecting the neural arch with the centrum are traceable, there has been a certain degree of anchylosis, which has helped to maintain the arch in its natural connection, notwithstanding the degree of pressure and distortion to which the whole vertebra has been subject. Each neurapophysis, which measures one inch five lines in antero-posterior diameter at its narrowest part, is smoothly rounded off at both its free borders, of which the anterior one is the thickest; the posterior zygapophysis is developed at rather more than an inch above the base of the neurapophysis; its flat oval articular surface looks downwards, and a little outwards: the neural canal is relatively wider than in the *Plesiosaurus Bernardi*, and its area is oval, with the great end downwards. The spinous process, of which nearly four inches is preserved, has an antero-posterior diameter at its base, of nearly two inches, and is strengthened behind by two buttress-like ridges, which rise converging from the summit of each posterior zygapophysis: bounding an angular depression at the back part of the spine, as in the *Plesiosaurus Bernardi*, and many other species. The total height of this vertebra, as far as the spine is preserved, is seven inches and a half, and the total length of the Plesiosaurus, to which it belonged, was probably not less than sixteen feet. There are preserved in the same block of Chalk with the vertebra above described, the summit of the neural arch, with the base of the spine of another vertebra, and a portion of one of the long ribs of the thorax, fig. 1, *pl.*

PLESIOSAURUS PACHYOMUS, *Owen*. 'Enaliosauria,' Plates 28 and 29.

'Report on British Fossil Reptiles,' Trans. Brit. Association, 1839.

This species of *Plesiosaurus* was founded on certain remains discovered in the Upper Green-sand at Reach, about six miles from Cambridge, and placed by the Rev. Professor Sedgwick in the Wordwardian Museum of that University.

The specific name "*pachyomus*" relates to the unusual thickness of the humerus, the distal flattened end of which is one inch and a half thick, the breadth of the same part being only four inches and a half, and the length of the entire bone nine inches and a half. The contour of the articular head is transversely oval. The central part of the bone is occupied by a coarse cellular structure, one inch and a half in diameter, surrounded by dense osseous walls, three lines thick.

In the rich and instructive collection of Reptilian fossils, from the Cretaceous deposits in Cambridgeshire, in the possession of James Carter, Esq., M.R.C.S., of Cambridge, there are several vertebral bodies or "centrums" of the same species of *Plesiosaurus* which show the change of proportion in the breadth and depth of the

* Παχυς, thick, ὦμος, *humerus*, or arm-bone.

centrum which the vertebræ undergo as they pass from the region of the neck to that of the back, without corresponding alteration in the length of the centrum.

The following are dimensions of the most perfect specimens of these vertebræ:

	Anterior Cervical.		Middle Cervical.		Posterior Cervical.		Last Cervical.	
	In.	Lines.	In.	Lines.	In.	Lines.	In.	Lines.
Antero-posterior diameter, or length	1	9	2	0	2	0	1	10
Transverse diameter, or breadth	2	3	2	3	2	9	3	0
Vertical diameter, or height	1	9	2	3	2	6	2	7
Breadth of neural surface (middle)	—		0	$2\frac{1}{2}$	0	5	0	6
Breadth of neurapophysial pit	—		1	1	1	3	1	9
Breadth of costal surface	—		1	0	1	$0\frac{1}{2}$	—	
Height of ditto	—		0	10	1	0	—	
Distance between neurapophysial and costal pits	1	0	0	9	0	$7\frac{1}{2}$	—	

The above dimensions show that whilst the centrums retain the length of two inches in the middle and towards the posterior parts of the long neck, they become shortened in the penultimate and last cervicals to the length of the smaller vertebra towards the anterior part of the neck; the difference, however, is but slight, and whilst an almost uniform length is retained, the vertebral centrums augment in height, and still more in breadth, as they approach the region of the back.

With the increased breadth of the centrum, there is a concomitant increase in that of the rough depressions (Pl. 29, figs. 3 and 4, *np*) for the articulation of the neurapophyses, and, at the same time, the bases of these vertebral elements become wider apart, and the breadth of the surface (ib. *n n*) supporting the neural axis, increases. This smooth surface which occupies the middle of the upper part of the centrum is contracted in the middle by the approximated neurapophysial pits, where there is on each side the orifice of the canal for the vertebral vein or sinus which traverses the centrum vertically. The lower openings of these canals are shown in Pl. 29, figures 2 and 5, and their whole course is displayed in the fractured vertebra rrepresented in fig. 6, *c c'*.

The costal pits in the greater proportion of the cervical vertebræ present the form of a full transverse ellipse, as in Pl. 28, fig. 1, and are situated below the neurapophysial pit at a distance about equal to their own vertical diameter. They are nearer the posterior than the anterior surface of the vertebra, and thus differ in position as in shape from the costal surface in Pl. 27, fig. 3, *pl*. As the cervicals approach the dorsal region the costal pit increases in vertical extent, assumes a circular form, and, as in all *Plesiosauri*, begins to rise towards the neurapophyses. The commencement of this

change in form and position of the costal pit, *pl*, is shown in Pl. 28, fig. 3, and its borders are here seen to be rather prominent. In none of the vertebræ has the costal pit presented the groove which, in most Plesiosauri, crosses it in the axis of the vertebra and divides it into two subequal parts. The articular ends of the centrum are slightly concave and are impressed by a circular pit at the centre; the peripheral margin is rounded off; it appears in the side view of the vertebra, Pl. 28, fig. 3, but not to such an extent as in *Plesiosaurus Bernardi*, Pl. 26, fig. 2. The lower apertures of the venous canals are closely approximated in all the cervicals except the most posterior ones, in which the canals diverge, as they descend, with a proportionate breadth between their lower outlets, *c' c'*, fig. 2, Pl. 29. They are divided by a narrow ridge, as in fig. 5, in the ordinary cervical vertebræ, and are not situated in fossæ, as in the *Plesiosaurus Bernardi*, Pl. 26, fig. 4.

In the vertebra which I take to be the penultimate or antipenultimate cervical, the upper half of the costal surface has passed upon the base of the neurapophysis, and, from what remains upon the centrum, as at *pl*, fig. 5, Pl. 28, we may see that the surface has undergone a further change of form, and has exchanged the circular (as in fig. 3) for a vertically elliptical or oval figure.

In the centrum of the last cervical vertebra figured in Pl. 29, figs. 1, 2, 3, the last trace of the costal surface is shown at *pl*, fig. 1. And I may here remark, that, as there is no definite natural distinction between the cervical and dorsal regions of the Plesiosaurus; the vertebræ in both supporting ribs, and the transition in the size, shape, and position of these being more gradual than in the Crocodiles, I have selected the arbitrary character of the impression of the costal articular surface, or any part of it, upon the centrum, as the character of the cervical vertebræ in the *Plesiosaurus*, and I count that to be the first dorsal in which the costal surface has wholly ascended upon the neurapophysis.

In Pl. 29, fig. 7, one of the caudal vertebræ is figured showing the longitudinal channel, at the middle of the under surface, bounded by the ridges which terminate on the articular surfaces for the hæmapophyses: those surfaces are here worn away. The neurapophyses have coalesced with the centrum; and the ribs have also coalesced, forming the 'transverse processes' of this caudal vertebra.

Plesiosauroid Paddle. Enaliosauria, Pl. 30.

The block of Chalk from the pit at Burham, in Kent, figured in Pl. 30, includes parts of four digits of the same foot, the phalanges of which had the opposed ends flattened, and joined together by ligament, the whole forming part of the bony framework of a large fin, most resembling that of the *Plesiosaurus*. This fine specimen forms part of the rich Collection of Chalk-fossils belonging to Mrs. Smith, of Tonbridge

Wells. Had Cuvier's conjecture, that the extremities of the *Mosasaurus* resembled those of the *Plesiosaurus*, been supported by the evidence of such remains of extremities referable to *Mosasaurus* as have been discovered since his time, the present remarkable specimen from the Chalk Formations of Kent, might have been ascribed with some degree of probability to the great Lacertian of the Maestricht Chalk. But the evidence which has been adduced from the remains of extremities of the *Mosasaurus* from the Green-sand of New Jersey, in the United States,* is incompatible with the supposition that the phalanges of the *Mosasaurus* were united by flattened surfaces and syndosmosis. No remains of the Mosasaurus, so far as I know, have been discovered in the Chalk-pit at Burham, but some vertebræ of *Plesiosaurus* have been obtained from thence, including the fine one figured in Pl. 27. In the specimen figured in Pl. 30, fig. 1, three phalangeal bones, and part of a fourth are preserved in one digit, three phalanges in the adjoining digit, and one phalanx of the next, which, if it be in its natural relative position, would belong either to the outermost or the innermost digit; and this is the more likely, as the phalanx of a fourth digit is on the same parallel with the proximal phalanges of the two best preserved digits. In the paddle of the *Plesiosaurus* the phalanges of the three middle digits are on the same transverse parallel, whilst those of the outer and the inner digits are on a higher or more 'proximal' plane.

I conclude, therefore, that the phalanges marked *ii, iii,* and *iv,* are the middle ones of a pentadactyle paddle, and that the phalanx marked *v* has belonged to either the inner or the outer terminal digit. If the fragment of bone that closely adheres by a flat surface to the proximal end of the phalanx *ii,* belong to the small carpal bone which articulates with the second digit in the paddle of the *Plesiosaurus,* we must consider the phalanx to which it is attached, and the two parallel phalanges, as appertaining to the proximal series: but that fragment may be a remnant of a proximal phalanx itself. The proximal surface of the three phalanges is slightly concave: the shaft of the phalanx is thick and strong; rather compressed from before backwards; gradually contracting to the middle part. Their substance presents a coarse cancellous texture throughout, with the cells or intervals widest at the middle of the bone. The parts being represented of the natural size, it is unnecessary to specify the dimensions of the phalanges. If the length of the proximal phalanx be taken with the compasses in digits *iii* and *iv,* it will be found that the two following phalanges progressively decrease in length. On the supposition that the phalanges of these digits are the first, second, and third, we may estimate the length of the entire paddle, according to the proportions of that of the *Plesiosaurus Hawkinsii,* at sixteen inches; which would accord with the proportions of the vertebra of the Plesiosaurus from the same pit, figured in Pl. 27.

* Quarterly Journal of the Geological Society, Jan., 1849, See also, ante, pp. 191—193.

In the instructive Collection of THOMAS CHARLES, Esq., of Maidstone, is part of a single digit of the paddle of apparently the same species of *Plesiosaurus.* It includes three phalanges, and part of a displaced small phalanx of an adjoining digit. In comparison with the more perfect paddle in Mrs. Smith's collection, I regard the phalanges in the present specimen as being the third, fourth, and fifth of their digit.

Genus, ICHTHYOSAURUS.

If the investigation of the fossil remains of the Chalk-beds had been undertaken by the Comparative Anatomist, without previous knowledge of the fossils of the lower secondary formations, he would have perceived in the teeth which form the subjects of 'Enaliosauria,' Pl. 1, characters not only specifically, but generically, distinct from any of the teeth that have been previously described and figured in the present Work. The thick conical crown covered by enamel, raised into numerous longitudinal ridges, would have offered, it is true, a repetition of the general character of that of the teeth of *Polyptychodon;* but the continued expansion of the base or fang of the tooth, and the coarser longitudinal ridges and grooves with which most of the surface of that part is sculptured, would be a peculiarity distinguishing the present from any of the previously noted teeth from the Cretaceous or Tertiary series, and still more so from the teeth of any known existing Reptile. It is only, indeed, those of the largest Crocodiles or Alligators that can compete with the present fossil teeth from the Chalk-formations in point of size; and the crowns of these, as in the teeth of the *Polyptychodon,* differ from the teeth of the *Crocodilia* in the absence of the two opposite ridges, forming or indicating the edges of the crown; whilst their base also differs from that of the Crocodile's tooth in the structure above defined,—a difference which becomes more manifest when a section of that part is made, demonstrating that the expanse of the fang is due to the unusual thickness of the osseous external crust called 'cement.' The Anatomist, I say, would be justified in deducing from these characters the generic distinction of the Reptile to which they had belonged, but he could have formed no suspicion of the truly extraordinary modifications of the entire reptilian organisation that had been associated with such generic modifications of the teeth. Such fossil teeth, having a conical, enameled, and commonly striated crown, offering a considerable range of variation in its proportions, and supported by an expanded, usually solid, and coarsely-grooved fang, covered by a thick coat of cement, have been recognised, since the publication of Sir Everard Home's Paper 'On the Remains of an Animal linking the class of Fishes to that of the Crocodile,' published in the Philosophical Transactions for 1814, as belonging to that genus of animal to which Home gave the name of *Proteosaurus,* but to which Naturalists have concurred in applying the more classically

constructed and appropriate name of *Ichthyosaurus,* suggested for it by the estimable and accomplished keeper of the Mineralogical Department of the British Museum, Charles König, K.H., F.R.S.

Remains of species of *Ichthyosaurus* are found in secondary strata from the Chalk down to the Muschelkalk, and most abundantly in the Oolite and Lias. In my 'Report on the British Fossil Reptiles,' I recorded the discovery of "portions of the lower jaw with teeth of a large species of *Ichthyosaurus* from the lower Chalk between Folkstone and Dover, which was closely allied to the *Ichthyosaurus communis.* And in the description of the Fossil Reptilia in Mr. Dixon's work 'On the Geology of Sussex, some teeth from the Chalk of Kent, now preserved in the Museum of William Harris, Esq., F.G.S., are figured in T. XXXIX, fig. 10, where they are stated to belong to the genus *Ichthyosaurus,* and to correspond so closely in form and size with those of the *Ichthyosaurus communis,* that I did not presume, in the absence of any knowledge of the skeleton, to pronounce them to belong to a distinct species.

I have since been favoured with the opportunity of studying and comparing the required parts for yielding more satisfactory characters, and have arrived at a conviction of the distinction of the species of Ichthyosaur of the Chalk-epoch from that of the Lias, which it most resembles in the general shape and proportions of the teeth, a distinction first recognised by James Carter, Esq., M.R.C.S., of Cambridge, who proposed for the species the name of *Ichthyosaurus campylodon,* at the 'Meeting of the British Association' at that University in 1846, on the occasion of the exhibition of some fine remains of the species obtained by him from the Lower Chalk, in the vicinity of Cambridge, in 1845. Before describing these remains, I shall give an account of the additional specimens from the locality whence I derived the first evidence of the presence of remains of the *Ichthyosaurus* in the Cretaceous strata.

Ichthyosaurus campylodon, *Carter.* Lower jaw, 'Enaliosauria,' Plate 4.

In the operations upon the Chalk-cliffs connected with the Dover Railway, a considerable proportion of the lower jaws and fragments of the ribs of a large *Ichthyosaurus* were brought to light; they were dislodged from the hard gray chalk at the end of the Round Down Tunnel, about two miles and a half from Dover, under the cliff, four feet from the beach beyond "Shakespeare's Cliff," towards Folkestone.

The specimens are now in the collection of H. W. Taylor, Esq., of Brunswick Place, Brixton Hill, to whose kindness I am indebted for the present opportunity of describing and figuring them.

The principal portion consists of four coadaptable fragments of the left ramus of the lower jaw, including nearly the whole of the dentary piece and fragments of the splenial and angular pieces, the whole measuring two feet seven inches in length, but

without the natural anterior termination, and wanting all that extensive hinder part of the ramus formed by the angular and surangular pieces. The inner alveolar plate of the dentary is broken away; but the vertical diameter of the outer part of the bone, from being 2 inches 6 lines at the hinder end, gradually decreases to 1 inch 9 lines at the fore part. A few teeth have been cemented to the alveolar plate in the anterior fragments, and perhaps in the places near which they were found, for numerous scattered teeth of the *Ichthyosaurus campylodon,* and doubtless of the same individual as the jaws, were exposed in the fragments of the Chalk rock containing those parts.

The outer surface of the dentary bone, Pl. 4, fig. 1, is convex, the inner surface at the part where the second joins the third fragment, about 1 foot 6 inches from the anterior end, is divided into two longitudinal channels by the base of the inner alveolar wall; which base is perforated lengthwise by the dental canal. As we trace this part of the dentary backwards, the alveolar groove progressively shallows and diminishes, and the lower groove widens and increases; the section of the dentary at the back part of this fragment, two feet from the fore end of the whole portion of the bone preserved, presenting a sort of hour-glass form, the upper and under portion being connected by a very thin plate. The form of the section displayed at the fractured end is given in Pl. 4, fig. 1*. The coarser central osseous texture appears to have been included within a thin, dense, exterior crust, about a line in thickness, and the same crust surrounds the canal *c*. The outer surface of the dentary piece shows a shallow groove about two thirds of an inch below the outer alveolar border, into which groove the several vascular foramina open which are continued from the canal, fig. 1 *c*.

The portion of the right ramus of the same lower jaw, Pl. 4, fig. 2, includes the termination of the splenial pieces with the commencement of the symphysis, and includes an extent of the dentary piece, 32, measuring one foot three inches in length. The vertical diameter of the dentary at the hinder fractured end, fig. 2*, is three inches, and at the front end, fig. 2**, is two inches two lines. The inner alveolar plate is sent off about an inch below the upper border of the thick outer plate; and forms the floor of the groove before it rises to form the inner wall; it slightly increases in thickness in forming the rounded border of that wall; the diameter of the floor of the socket is three lines: the depth of the alveolar groove is two inches three lines, its breadth is ten lines and a half. Portions of both splenial bones, somewhat dislocated, shown at 31, 31.

The cavity in the dentary beneath the alveolar wall is reduced to a mere groove midway between the fractured ends, with the exception of which the whole of the now flattened inner surface of the dentary is in contact with its fellow, forming the strong and long "symphysis menti." At the fore part of the fragment the alveolar groove is reduced to a depth of eleven lines, and a breadth at its outlet of nine lines. One of the transverse canals is exposed at the anterior fracture, which passes from the inner longitudinal canal to the outer groove. Wherever the bone is broken, that modification

of its outer surface is shown, which gives it the appearance of forming a crust about a line in thickness, of a different texture from the rest of the bone.

The fragment, Pl. 4, fig. 3, is a portion of the right premandibular bone, showing a cast of the dental vasculo-nervous canal, and the outlets terminating at the orifices on the outer side of the bone.

The teeth, supposing them to have been correctly restored, decrease in size, as in the *Ichthyosaurus communis,* near the anterior end of the dentary piece.

The largest tooth in this portion of the jaw, placed one foot from the anterior end, has a crown eleven lines in length, straight, conical, rather obtusely pointed, five lines and a half in diameter, with numerous, not very sharp, but close-set ridges, narrowing as they approach the summit, and subsiding before they attain it. The cement-covered base continues to expand as it descends, with a smooth exterior for about one third of its extent from the crown, and with coarse longitudinal striations or wrinkles over the rest of its extent. The surface of the base in most of the teeth, like the surface of the bone, is coated by a firm crust, sparkling with minute crystals of pyrites. In the attempt to remove this coating, the parts have been more or less injured, so that the precise character of the external markings, and original shape of the thickened fang, cannot be ascertained. The transverse section of the crown of the tooth is circular at its apical half, but widens into a full ellipse towards the base; that of the smooth beginning of the base is a modified ellipse, which in the rougher and more expanded part of the base, seems to take on a subquadrate form.

The teeth differ in size at different parts of the jaw; in the first or foremost of the series the crown of the tooth is only four lines in length in the lower jaw, and it gradually increases to eight and ten lines in length,—the total length of the longest tooth being two inches and a half. Some of the scattered teeth adherent to the present fragments having very short and thick crowns. In fig. 4, the crown is as wide at its base as it is long: a portion of the thick cement has been removed from the fang just below the crown, and exposes the grooved exterior surface of the dentinal base of that part of the tooth.

In the *Ichthyosaurus communis*, the teeth of which most resemble those of the present species from the chalk, the crown of the tooth tapers more gradually to the apex; and the enamel ridges are immediately continued upon broader rounded ridges of the cement-covered fang, which become more strongly marked as the fang recedes from the crown, and are divided by deep grooves, giving a fluted character to the base of the tooth, which is proportionally less expanded, and retains more of the circular form in transverse section. (See 'Enaliosauria,' Pl. 1, fig. 17.)

In the few more or less imperfect teeth of the *Ichthyosaurus* from the chalk, which I had seen whilst drawing up, in 1838, my Report on 'British Fossil Reptiles,' the differences above specified were not manifested so clearly as in the more numerous and complete examples which have since been submitted to me. The smooth exterior

of that part of the fang next the crown, in the *Ichthyosaurus campylodon,* is due to a thick coat of cement; the dentine so covered shows a fluted character, only differing from that of the teeth of the *Ichthyosaurus communis* in being more regular and somewhat finer. This is shown in Pl. 4, fig. 4.

Not any of the detached teeth discovered with the above-described portions of jaw present any well-marked curvature of the base. The characteristics of the teeth of the *Ichthyosaurus campylodon* are best displayed in those specimens that have been obtained from the cretaceous deposits in Cambridgeshire.

Teeth of Ichthyosaurus campylodon. 'Enaliosauria,' Plate 1.

The detached teeth from the Cambridge Chalk and Green-sand present two modifications of form: the majority are straight, the rest curved, chiefly owing to a slight inward bending of the thickened fang. These latter have been proved to come from the lower jaw, and the curvature relates, as Mr. Carter has well remarked, to the more oblique direction outwards of the alveolar groove in that jaw, which is compensated by the curvature of the teeth, the crowns of which are thereby brought into more direct apposition with the teeth above.*

The enameled crown in all the teeth (figs. 1, 2, 6 *c*) is a cone, short and thick in the largest teeth, with a circular or very full elliptical transverse section; it is a longer and narrower cone in most of the smaller teeth. The ridges of the enamel are numerous and fine, not always of equal thickness; the intervening grooves are rather narrower than the ridges. In some teeth, shorter and narrower ridges are seen in the basal intervals of the longer ridges: in other teeth the ridges are thicker at the base of the crown, and are occasionally impressed or divided there by a shorter longitudinal groove. All the ridges subside before they reach the apex of the crown, which is smooth. The enamel terminates at the base of the crown by a thin well-defined border. The tooth continues to expand beyond this border, and, for an extent varying from one third to one fifth of the entire fang. The surface is smooth; not any of the longitudinal furrows or ridges of the enameled crown being continued upon that part of the cement-covered fang. In a few teeth, the base of the crown is well defined, as Mr. Carter has remarked, by an annular projection, Plate 1, figs. 3 and 4. The rest of the base or fang of the tooth, beyond the smooth part, presents coarse longitudinal ridges and grooves, is much expanded in most of the teeth, and in many it presents, as in the tooth figured and described by Mr. Carter,† a square shape. This character is best marked in the straight teeth from the upper jaw; it arises out of the progressive growth of the osseous cement of the fang, which seems to have

* London Geological Journal, vol. i, p. 9.

† Loc. cit., p. 8, figs. *a* and *b*.

been only checked by the resistance of the alveolar walls on the outer and inner sides of the tooth, and by the contiguous teeth before and behind. Thus, by this thickening of the fang, the teeth must have become wedged together in the common alveolar groove, and the absence of partitions completing the sockets must have been in some measure compensated by this firm impaction. This is shown in the part of the fractured jaws. (Pl. 3, fig. 2.)

Figs. 3 and 4, Pl. 1, give two views of a portion of the alveolar groove with one tooth thus squarely wedged in its place, part of the adjoining tooth on one side, and part of the socket on the other, in which a thin bony partition had been formed for a short extent of the base of the tooth. The extent of the square root in the direction of the long axis of the jaw, fig. 4, is commonly greater than the transverse diameter of the same root, fig. 3. The tooth is never wholly consolidated even in this fully developed state of the fang: a remnant of the uncalcified pulp has always been retained in the central dentinal part of the enlarged fang, after the crown has been completed. This is shown in the fractured specimen, fig. 5, in which the square fang beyond the cavity, *o*, is one solid mass of coarse cement; and more clearly in the transverse section, fig. 6, in which *c* is the cement, *d* the dentine, and *a* the pulp-cavity. The view given at fig. 6′ shows the consolidated base of the thickened fang,—a character by which the teeth of the Ichthyosaurs differ from those of almost all other Saurians, and especially from the Crocodiles, in which the base of the tooth always remains widely open.

Notwithstanding, however, the resistance which must be opposed by the thickened and consolidated root of the tooth of the Ichthyosaur, it is affected by the germ of the succeeding tooth in the same way as in the *Crocodilia*. I have seldom, indeed, seen the process better illustrated than in a series of the teeth of the *Ichthyosaurus campylodon* in Mr. Carter's collection, obtained from the Chalk in the neighbourhood of Cambridge.

Fig. 7, Pl. 1, is a tooth with a thick, straight, square fang; probably, therefore, from the upper jaw, which shows on one of the broader sides of the base a shallow elliptical depression, *o*. This is caused by the progressive absorption excited by the pressure of the soft matrix of the successional tooth which was in the course of development at the angle of the alveolar groove on the inner side of the base of the tooth in place. In the Ichthyosaur's tooth the absorption causes a simple excavation in the substance of the thick cement; but in the Crocodile's the same process speedily penetrates the thinner wall of the large cavity in the base of the tooth, as is shown in the figure of that of an Alligator (fig. 11), where a circular aperture is the result of the pressure. As the new tooth of the Ichthyosaur grows, the thick cement of the old tooth yields, and the reduced pulp-cavity in the centre of the fang is penetrated, as is shown at fig. 8, *o*, where the absorbent process has extended nearly across the whole solid base of the fang, fig. 8′. In fig. 9 the germ of the tooth is preserved, which has penetrated

the breach so excavated; and as both this and the preceding tooth (fig. 8) are from the lower jaw, the direction in which the fang is bent demonstrates that the germs of the new teeth were developed from the inner angle of the bottom of the alveolar groove, and affected the inner side of the base of the fully formed teeth, as in the Crocodiles. In fig. 10 the crown and the smooth beginning of the fang of the successional tooth have been completed, and it is seen enclosed by part of the debris of the old tooth which it is about to replace. As in all young teeth, the crown is a thin shell of the first-formed layers of dentine, with a thin coat of enamel, the ridges of which seem not to have been quite completed.

The teeth of the Ichthyosaurus are smaller at the two extremes than at the middle of the series in both jaws; and some modifications of form are presented in these teeth, which do not, however, overpass the recognisable limits of the specific characters.

Fig. 13 is a tooth probably from the back part of the series in the upper jaw, in which the crown is less broad at its base and relatively longer than in the large teeth from the middle of the series; the rough expanded fang presents in transverse section a long ellipse, with its angles truncated, making but a slight approach to the quadrate figure of the fang of most of the larger teeth; but in the fine striation of the conical enamelled crown, in the smooth tract of unenamelled fang which precedes the roughly striated expanded portion, and in the degree of expansion of this part, all the distinctive characters of the *Ichthyosaurus campylodon* are preserved.

Figure 14 is an incompletely formed tooth from the opposite end of the dental series, in which the enamelled crown is unusually short and thick; but the smooth surface of the portion of the fang which has been formed, which continues to expand to the widely open pulp-cavity, gives the character of the same species as fig. 13.

In fig. 15, from the Upper Green-sand, we have a tooth in a more advanced stage of formation: the roughened thickened part of the base has begun to be added; but this is still widely open, as is shown in fig. 15′.

In Figure 16, a greater proportion of the rough expanded fang is completed, and the basal outlet of the pulp-cavity is beginning to be encroached upon: but in these young teeth the cement has not increased in such quantity as to be moulded into the square form that is so characteristic of the old teeth.

Jaws of the Ichthyosaurus campylodon, from the Cambridge Chalk.
'Enaliosauria,' Plates 2 and 3.

The portions of the upper and lower jaws discovered with the teeth above described, and containing several teeth of the same character *in situ*, are, as their possessor, Mr. Carter, truly describes, the most characteristic relic of the Ichthyosaurian genus hitherto obtained from the Cretaceous Formations.

The portion of the upper jaw includes an extent of two feet of the premaxillary

bones, including at the back part about three inches of the exposed, and apparently pointed terminations of the nasal bones (Pl. 2, fig. 2, 15.) These, however, extend much further forwards than they appear to do externally, their anterior ends being overlapped by the premaxillaries, 22. The breadth of the premaxillaries at the fractured hinder end of this specimen is $5\frac{1}{2}$ inches, at the distance of one foot from that fractured end it is $3\frac{1}{2}$ inches, and the decrease seems to have been rather more gradual in advance of this part. The total length of the jaws from the point of union of the premaxillaries above the nasals, may therefore be estimated at about three feet.

The breadth of each nasal, where they dip beneath the premaxillaries, is one inch three lines: the upper surface presents a longitudinal furrow midway between the margins of the bone, into which furrow a longitudinal ridge at the under surface of the premaxillary fits, thus strengthening the union between the two bones. The nasal bone forms a parallel ridge, or angular projection, from its own under surface, which divides the inferior concavity into two parts, the median and broader concavity being somewhat angular in form. The actual pointed ends of the nasals are visible at a fractured surface, (Pl. 3, fig. 2, 15,) nine inches in advance of the point where they are concealed by the median junction of the premaxillaries: their section here presents the form of a curved lamina of bone, thickest at its median border, and half an inch in breadth, and this may be traced beneath the fractured portion of the premaxillary three inches further forwards.

The breadth of the nasal cavity at the back part of the fractured end, (Pl. 3, fig. 1,) is rather more than two inches: at the anterior fracture, fig. 2, it is reduced to ten lines.

The median borders of the premaxillaries, (Pl. 3, fig. 1, 22,) before their junction above the nasals, (ib. 15,) are about one line thick, and the bone increases to a thickness of three lines, above the part where it sends off, inwards and downwards, the inner alveolar border, (ib. *al,*) which is at a distance of an inch and three fourths from the upper median border. On the outside, opposite the origin of the inner alveolar plate, the premaxillary is traversed by a straight longitudinal groove, (Pl. 2, fig. 1, *g,*) four lines in breadth, which contracts, as it advances forwards. The outer alveolar plate, (Pl. 3, fig. 1, *a,*) increases in thickness to six lines, and terminates below in a convex border. The inner alveolar plate, (ib. *al,*) forms the chief part of the arched roof of the upper dental groove, and has there scarcely a line in thickness; but as it descends, it rapidly gains a thickness of five lines at its inferior convex border. There is a slight solution of continuity between the arched and descending portions of the inner alveolar plate, (ib. *al',*) at the hinder fractured end of the specimen, and the descending plates might at first sight be taken for the palatine bones; but these, in other *Ichthyosauri*, are vertical plates, which lie parallel with, and on the inner side of the descending alveolar plate of the premaxillary, and do not reach so far forwards as where the nasals are wholly overlapped by the premaxillaries. The inner alveolar

plate descends eight lines lower than the outer one, and the outlet of the alveolar groove has a corresponding oblique aspect downwards, and a little outwards: the breadth of the groove at the outlet is 1 inch 2 lines: the depth of the groove, to the inner border, is 1 inch 6 lines: the breadth of the alveolar part of the premaxillary, including the plates, is 2 inches and a half. At the anterior fractured end of the left premaxillary, (Pl. 3, fig. 2, 22,) ten inches in advance of the hinder fracture, the vertical diameter of the bone is 2 inches 10 lines, the breadth of the lower alveolar part is 1 inch 9 lines, the depth of the alveolar groove is 1 inch 5 lines, the breadth of its outlet 1 inch 1 line. Here the two premaxillaries are in contact at the upper borders, which have progressively increased, after overlapping the nasals, to a thickness of 7 lines, The inner alveolar plate is sent off about half an inch below the upper border, extending inwards and downwards, and dividing the nasal from the alveolar groove, then descending, in contact with the same plate of the opposite premaxillary, for about an inch of vertical extent: the thickness of the plate near its origin is 3 lines, whence it increases to 7 lines at its lower rounded border, ib. *al''*. The elliptical area of a canal, 4 lines in diameter, *o*, is exposed above the origin of the inner alveolar plate. The narrow exterior groove, *g*, sinks 3 lines into the substance of the bone, and slightly expands towards its bottom. The outer groove and the inner canal communicate by transverse anastomosing channels at certain parts.

The whole of the upper surface of the premaxillaries forms a smooth arch of bone, describing in transverse section a semicircle, and impressed only by the longitudinal groove each side, for the lodgement of a vessel on and probably also a branch of the fifth pair of nerves.

The portion of the lower jaw consists of the dentary and splenial pieces,* both dislocated, the former slighly. At the back part of the left ramus, (Pl. 3, fig. 1,) the lower border of the splenial, (ib. 31,) has been pressed inwards and downwards from that of the dentary, (ib. 32,) and slightly rotated so as to incline its inner vertical wall outwards, where it is pushed into the groove or concavity of the dentary, which it naturally closes, applying itself to the side of the inner alveolar plate of the dentary. The right splenial, (ib. 31,) has been still more displaced, its lower border being pushed against the base of the inner alveolar plate of the left ramus.

Both splenials are exposed at the anterior fracture of the rami, (Pl. 3, fig. 2,) six inches in advance of the preceding, the right being here, also, above the left, and removed from its own ramus to contact with the base of the inner alveolar plate of the left ramus. The vertical diameter of the splenial, which is two inches at the hinder fractured part, has diminished to little more than one inch at a distance of five inches

* See the Cut, fig. 13, p. 9, of the 'Fossil Reptilia of the Tertiary Formations,' Chap. ii, *Crocodilia,* in which the different pieces of the complex lower jaw of the Alligator is figured: and where 29 is the "articular," 29' the "surangular," 30 the "angular," 31 the "splenial," 31' the "complemental," and 32 the "dentary."

in advance of this. The splenial has the same shape as in other *Ichthyosauri*, being a longitudinal plate, with its lower margin bent outwards at a right angle; this margin forms the lower border of a great extent of the ramus, underlapping the dentary at the situation of the posterior fracture, which is a little prior to the junction of the two rami forming the symphysis; it is withdrawn to the inner side of the dentary at the anterior fracture. The ascending or vertical plate of the splenial forms the largest part of the bone, and is much thicker than in the Crocodile with a jaw of the same depth: its transverse diameter in the present Ichthyosaur is 3 lines.

The dentary is a long bone which, at the hinder fractured part, (Pl. 3, fig. 1, 32,) appears as if it were folded lengthwise twice upon itself, forming a sigmoid transverse section; but the outer part of the bone increases in thickness as it advances forwards, and the inner alveolar wall presents, at the anterior fracture, more the appearance of an accessory plate or process sent off from the inner side of the body of the bone. The vertical diameter of the dentary pieces is 2 inches 3 lines.

The outer part of the dentary at the hinder fracture is 6 lines in thickness, smooth and convex on its outer side, which is traversed by a longitudinal groove, *g*, which also slightly narrows as it advances. The alveolar plate is continued downwards and inwards at an angle of about 50°, diminishing in thickness as it descends, and again increasing after it has risen, to form the inner wall of the alveolar groove. The depth of the groove is 1 inch 5 lines; its width is 1 inch. At the anterior section, 5 inches in advance, (Pl. 3, fig. 2,) the alveolar groove (*ac*) has contracted to a diameter of 8 lines, and is 1 inch 2 lines in depth; the inner alveolar wall, (*al*,) has increased in thickness.

The lower jaw, in the present fine fragment of skull, appears to have been broken across just anterior to the meeting of the two rami, where they form the symphysis.

What is wanting in the specimen of the *Ichthyosaurus campylodon* in Mr. Carter's collection to give, *ex visu*, the proportions of the jaws of that species, is, in great part, supplied by the fragments from Mr. Taylor's collection, which had been previously discovered in the Grey Chalk near Dover.

The hinder end of the portion of the left ramus in that specimen, which measures 2 feet 7 inches in length, has been broken away from the part which corresponds with the front end of the portion of the same bone in Mr. Carter's specimen, and this end is nearly 1 foot distant from the hindmost part of the same specimen. We thus gain an extent of jaw by this addition of nearly 3 feet, and at least 1 foot more would be required to complete the whole length of the jaw.

Owing to the partial dislocation of the rami, the aspect of the alveolar groove is more outwards than is natural; but in the proper relative position it is turned more obliquely outwards than that of the upper jaw, and the roots of the lower teeth, as Mr. Carter has well remarked, present a curvature which compensates for the obliquity of this alveolar groove, and gives a more vertical direction to their crowns.

This characteristic of the present species is well shown in the group of upper and lower teeth preserved on the right side of the present instructive fragment of the skull, (Pl. 2 and Pl. 3, fig. 2.) It includes, in an extent of 6 inches and 9 lines, six teeth of the upper jaw; and, in an extent of 4 inches and a half, four teeth of the lower jaw. Besides the teeth which have preserved nearly their natural positions in respect of each other, there are three or four displaced teeth or fragments of teeth. Of the four teeth of the lower jaw, the three largest, while they have kept nearly their natural position to the teeth above, have slipped out of the groove of the lower jaw during its downward displacement, instead of being separated to the same extent from the upper teeth. In the lower jaw of the Cachalot, where the teeth are lodged in a wide groove, and with the alveoli incompletely developed, they are easily dislodged when decomposition has commenced, and may be stripped away with the firm gum, to which the necks of the teeth adhere more strongly than their fangs do to the rudimental sockets.

The first of the six teeth of the upper jaw is completely formed, and shows the quadrate root a little compressed in the transverse direction. The rough part of the fang is that which is embraced by the sides of the alveolar grove; the smooth portion was probably surrounded by a soft slimy gum as far as the enamelled crown. The tooth opposed to this in the lower jaw, and the crown of which passes, as usual, external to it, is a young tooth, with the fang as yet incompletely formed and rounded: its inferiority of size to the tooth above depends on this circumstance. The second tooth above is not so far advanced in growth as the one which precedes or the four that follow it; the crown and part of the fang of the last, *m*, of these are broken away, and expose the germ of the young tooth, *t*, which had penetrated its cavity and was about to displace it. The curve of the rough expanded fangs of the lower teeth is well exhibited in the last two of these teeth.

The teeth of the *Ichthyosaurus campylodon* are large in proportion to the slenderness of the elongated jaws, and offer, in this respect, a great contrast with those of the *Ichthyosaurus tenuirostris:* they are even larger in proportion than the teeth of the shorter and thicker jawed *Ichthyosaurus communis* and *Ichthyosaurus lonchiodon*, and both the proportions and the form of the teeth determine the specific distinction of the present *Ichthyosaurus* of the Chalk and Green-sand from any of the known species from the older secondary strata. But there is no modification indicative of a departure from the generic characteristics of the great Fish-lizard: on the contrary, so far as these are manifested by the structure of the jaws, especially the undivided alveolar groove, by the great proportional size of the premaxillaries, and by the thickly cement-covered fangs of the teeth, these characters are rather in excess, and the last of the Ichthyosaurs, far from progressing towards any higher and later form of reptile, might be cited as a type of its peculiar genus.

Vertebræ of Ichthyosaurus Campylodon. 'Enaliosauria,' Plate 7.

Had no other part of the *Ichthyosaurus* been discovered in the Chalk Formations than the centrum of a vertebra, that alone would have sufficed to convince the investigator, who had commenced his researches by descending from the more recent to the older Formations, that some marine Saurian had existed totally distinct from any other Reptile the remains of which he might have previously met with in the chalk; if, indeed, a vertebra so far departing from those of the *Reptilia* in general had not been mistaken for the vertebra of a Fish. The most fish-like character of the Ichthyosaurus is the deep concavity of both articular extremities of the centrum, fig. 3, and the shortness of the vertebra, fig. 1, as compared with its breadth and height, fig. 2, in which proportion it resembles the vertebræ of the shark tribe. But the peripheral non-articular or free surface of the vertebra is smooth and entire: the articular depressions for the neurapophyses are shallow, and those for the ribs are situated on either one or two tubercles on each side of the centrum. Such pair of costal tubercles would alone suffice to distinguish the vertebra of the Ichthyosaurus from the biconcave vertebra of any fish. All the general characters of the Ichthyosaurian vertebræ are manifested by the specimen figured in Pl. 7.

It was discovered in the same mass of grey chalk at the base of Shakspeare's Cliff as the jaws and teeth figured in Pl. 4, and forms with these part of the collection of W. H. Taylor, Esq. It corresponds in its dimensions with those fine fragments of jaw, and might well have formed part of the vertebral column, which supported a head four feet in length.

The substance of the bone is decomposed, and the surface studded with firmly adherent pyritic matter. It appears to have come from the base of the tail, where the costal tubercles become single. The surface of the articular concavity has the gentle undulating disposition, convex at the periphery, before the deeper central concavity is scooped out, as shown in the section, (Pl. 7, fig. 3,) which is common to some other species of Ichthyosaurus; but no specific character could have been deduced from this fragment of the skeleton.

The vertebra figured measures 4 inches vertically across the articular concavity; and 1 inch 10 lines longitudinally across the side. A smaller vertebra from the middle of the tail measures $3\frac{1}{2}$ inches transversely, and $1\frac{1}{2}$ inch in antero-posterior extent. The concavity deepens rather suddenly towards the centre.

Three more or less mutilated bodies of vertebræ, having similar proportions to those of the *Ichthyosaurus campylodon* from the Dover Chalk, have been obtained from the Upper Green-sand near Cambridge, where they are also associated with teeth of the same species. They are preserved in the cabinet of James Carter, Esq., M.R.C.S.

In the *Ichthyosaurus tenuirostris*, the length of the lower jaw equals at least fourteen times that of the vertical diameter of the centrum of an anterior caudal vertebra; in the *Ich. communis* and in the *Ich. lonchiodon* eleven times; in the *Ich. intermedius* ten times the same diameter. The jaws of the *Ichthyosaurus campylodon* must have approached more nearly to the proportions of those of the *Ich. tenuirostris*, than the other species above named, and it is not unlikely that the lower jaw was thirteen times the length of the vertical diameter of an abdominal or anterior caudal centrum.

Assuming such proportions, we may reckon the lower jaw to have been upwards of four feet in length; and this calculation accords with that founded upon the proportions of the fragments of the lower jaws above described.

One of the masses of chalk contains portions of several ribs, the longest being about ten inches in length; the transverse section of these portions of rib is a regular full ellipse, the fractured end of one of the least mutilated is 9 lines in its long diameter, 6 lines in its short diameter; but some parts of the ribs are 1 inch in breadth. Not any of these fragments show the opposite longitudinal impressions that characterise some of the ribs in the *Ichthyosaurus communis*.

CHAPTER V.

ORDER. *PTEROSAURIA*, Owen.

Genus—PTERODACTYLUS, *Cuvier*.

The honour of having first made known the existence of remains of *Pterodactyles* in the Chalk belongs to the able Secretary of the 'Palæontographical Society,' JAMES SCOTT BOWERBANK, Esq., F.R.S. This indefatigable Collector had the good fortune to receive, in 1845, from the Chalk of Kent, the characteristic jaws and teeth, with part of the scapular arch and a few other bones of a well-marked species of *Pterodactylus*, and the discovery was briefly recorded in the 'Proceedings of the Geological Society of London' for May 14th, 1845,* with an illustrative plate. Mr. Bowerbank concludes his Paper by referring to a large fossil wing-bone from the chalk, which I had previously figured and described in the 'Geological Transactions,'† and remarks that "if it should prove to belong to a *Pterodactyle*, the probable expansion of the wings would reach to at least eight or nine feet. Under these circumstances," he says, "I propose that

* The author there states that the specimens were "obtained from the Upper Chalk of Kent:" Mr. Toulmin Smith, in his able paper "On the Formation of the Flints of the Upper Chalk" in the 'Annals of Natural History,' vol. xx, p. 295, affirms that no Upper Chalk exists in the localities whence those specimens came. They are from the Middle Chalk.

† Second Series, vol. vi, 1840, pl. 39, fig. 1.

the species described above shall be designated *Pterodactylus giganteus*," (loc. cit., p. 8.) Subsequent discoveries and observations have inclined the balance of probability in favour of the Pterodactylian nature of the fossils to which Mr. Bowerbank refers.

These fossils are not, indeed, amongst the characteristic parts of the flying reptile; one is the shaft of a long bone exhibiting those peculiarities of structure which are common to birds and Pterodactyles; the other shows an articular extremity which, in our present ignorance of the different bones of the Pterodactyle, has its nearest analogue in the distal trochlea of the bird's tibia. These two specimens, which are figured in the above-cited volume of the 'Transactions of the Geological Society,' Pl. 39, figs. 1 and 2, were, in fact, as I acknowledged in the Memoir, read April 26th, 1840, transmitted to me by the Earl of Enniskillen and Dr. Buckland, as being the bones of a bird (p. 411), and my comparisons of them were limited to that class.

The idea of their possibly belonging to a Pterodactyle did occur to me, but it was dispelled by the following considerations. The act of flight—the most energetic mode of locomotion—demands a special modification of the vertebrate organisation, in that sub-kingdom, for its exertion. But in the class *Aves*, in which every system is more or less adapted and co-adjusted for this end, the laws of gravitation seem to forbid the successful exercise of the volant powers in species beyond a certain bulk; and when this exceeds that of the Condor or Albatross, as, for example, in the Cassowary, the Emeu, or the Ostrich, although the organisation is essentially that of the vertebrate animal modified for flight, flight is impossible; and its immediate instruments, to the exercise of which all the rest of the system is more or less subordinated, are checked in their development, and, being unfitted for flight, are not modified for any other use. There is, perhaps, hardly a more anomalous or suggestive phenomenon in nature than a bird which cannot fly! A small section of the *Mammalia* is modified for flight; but the plan of the organisation of that warm-blooded class being less directly adapted for flight than that of birds, the weight and bulk of the body which may be raised and transported through the air, are restricted to a lower range; and the largest frugivorous Bat (*Pteropus*) does not exceed the Raven in size. The Reptilian modification of the vertebrate type would seem to be still less fitted for any special adjustment to aerial locomotion; and, in the present day, we know of no species of this class that can sustain itself in the air which equals a sparrow in size; this species, moreover, the little *Draco volans*, sails rather than flies, upborn by its outstretched costal parachute in its oblique leaps from bough to bough.

Of the remarkable Reptiles now extinct, which, like the Bats, had their anterior members modified for plying a broad membranous wing, no species had been discovered prior to 1840, which surpassed the largest of the *Pteropi*, or "Flying-foxes," in the spread of those wings, and there was *à priori* a physiological improbability that the cold-blooded organisation of a Reptile should, by any secondary modification, be made

to effect more in the way of flight, or be able to raise a larger mass into the air, than could be done by the warm-blooded mammal under an analogous special adaptation.

When, therefore, the supposed bird's bone, '*Pterosauria*,' Pl. 4, fig. 4, was first submitted to me by Dr. Buckland, which, on the Pterodactyle hypothesis, could not be the humerus, but must have been one of the smaller bones of the wing, its size seemed decisive against its reference to an animal of flight having a cold-blooded organisation. The subsequent discovery of portions of the skull of the Pterodactyles, figured in *ib.*, Pl. 3, shows that the manifestations of Creative power in past time surpass the calculations that are founded upon actual nature.

It is only the practised Comparative Anatomist that can fully realise the difficulty of the attempt to resolve a Palæontological problem from such data as the two fragments of bones first submitted to me in 1840. He alone can adequately appreciate the amount of research involved in such a generalization, as that "there is no bird now known, north of the equator, with which the fossils can be compared;" and when, after a wearying progress through an extensive class, the species is at length found to which the nearest resemblance is made by the fragmentary fossil, and the differences are conscientiously pointed out—as when, *e. g.*, in reference to the humerus of the Albatross, I stated that "it differs therefrom in the more marked angles which bound the three sides,"—the genuine worker and searcher after truth may conceive the feelings with which I find myself misrepresented as having "regarded the specimens as belonging to an extinct species of Albatross." My reference of the bones even to the longipennate tribe of natatorial birds, is stated hypothetically, and with due caution. "On the supposition that this fragment of bone is the shaft of the humerus, its length and comparative straightness would prove it to have belonged to one of the longipennate natatorial birds, equalling in size the Albatross," (loc. cit., p. 411.)

Since the discovery has been made of the manifestly characteristic parts of the genus *Pterodactylus*, in the Burham Chalk-pit, it has been objected that these bones first discovered there, and described by me as resembling those of birds of flight, "are so extremely *thin* as to render it most improbable that they could ever have sustained such an instrument of flight as the powerful wing of the Albatross or of any other bird: their tenuity is in fact such," says the objector, "as to point out their adaptation to support an expanded membrane, but not pinions."* This assertion needs only for its refutation a simple reference to nature; sections of the wing-bones of birds may be seen in the Museum of the Royal College of Surgeons, and have been exposed to view, since the discovery of their structure by the founder of that Collection, in every Museum of Comparative Anatomy worthy to be so called. To expose the gratuitous character of the objection above cited, I have selected for

* Mantell, 'Wonders of Geology,' 1848, vol. i, p. 441.

llustration in '*Pterosauria*,' Pl. 5, fig. 1, a section of the very bone that directly sustains the large quill-feathers in the Pelican: its parietes are only half as thin as those of the anti-brachial bone of the great Pterodactyle, figured in *ib.*, Pl. 4, fig. 1: they are thinner than those of the humerus figured in *ib*, Pl. 2, fig. 1.

HUNTER, who had obtained some of the long bones, with thin parietes and a wide cavity, from the Stonesfield Slate, has entered them in his MS. Catalogue of Fossils, as the "Bones of Birds:" and perhaps no practical anatomist had had greater experience in the degree of tenuity presented by the compact walls of the large air-cavities of the bones in that class. Of all the modifications of the dermal system for combining extent of surface with lightness of material, the expanded feather has been generally deemed the consummation. Well might the eloquent Paley exclaim:—"Every feather is a mechanical wonder—their disposition, all inclined backwards, the down about the stem, the overlapping of their tips, their different configuration in different parts, not to mention the variety of their colours, constitute a vestment for the body, so beautiful and so appropriate to the life which the animal is to lead, as that, I think, we should have had no conception of anything equally perfect, if we had never seen it, or can imagine anything more so." It was reserved for the author of the 'Wonders of Geology,' to prefer the leathern wings of the Bat and Pterodactyle as the lighter form, and to discover that such a structure, as is displayed in Pl. 4, fig. 4, was "a most improbable one to have sustained a powerful wing of any bird."

Let me not be supposed, however, to be concerned in excusing my own mistake. I am only reducing the unamiable exaggeration of it. Above all things, in our attempts to gain a prospect of an unknown world by the difficult ascent of the fragmentary ruins of a former temple of life, we ought to note the successful efforts, as well as the occasional deviations from the right track, with a clear and unprejudiced glance, and record them with a strict regard to truth.

The existence of a species of Albatross, or of any other actual genus of Bird, during the period of the Middle Chalk, would be truly a wonder of Geology; not so the existence of a bird of the longipennate family.

I still think it for the interest of science, in the present limited extent of induction from microscopic evidence, to offer a warning against a too hasty and implicit confidence in the forms and proportions of the purkingean or radiated corpuscles of bone, as demonstrative of such minor groups of a class, as that of the genus *Pterodactylus* Such a statement as that these cells in *Birds* "have a breadth in proportion to their length of from one to four or five; while in *Reptiles* the length exceeds the breadth of ten or twelve times,"* only betrays the limited experience of the assertor. In the dermal plates of the Tortoise, *e. g.*, the average breadth of the bone-cell to its length is as one to six: and single ones might be selected of greater breadth.

* Mantell, 'Wonders, &c.,' vol. i, p. 441.

With the exception of one restricted family of Ruminants, every Mammal, the blood-discs of which have been submitted to examination, has been found to possess those particles of a circular form: in the *Camelidæ* they are elliptical, as in birds and reptiles. The bone-cells have already shown a greater range of variety in the vertebrate series than the blood-discs. Is it, then, a too scrupulous reticence, to require the evidence of microscopic structure of a bone to be corroborated by other testimony of a plainer kind, before hastening to an absolute determination of its nature, as has been done with regard to the Wealden bone, figured in the ' Geological Transactions," vol. v, pl. xiii, fig. 6?*

As a matter of fact, the existence of Pterodactylian remains in Chalk was not surmised through any observation of the microscopic structure of bones that are liable to be mistaken from their more obvious characters for those of birds, but by the discovery of the characteristic portions of the Pterodactyle, defined by Mr. Bowerbank, as follows, in his original communication of their discovery to the ' Geological Society of London,' May 14th, 1845.

"I have recently obtained from the Upper Chalk† of Kent, some remains of a large species of *Pterodactylus*. The bones consist of—

1. "The fore part of the head, as far as about the middle of the *cavitas narium*, with a corresponding portion of the under jaws,—many of the teeth remaining in their sockets, (see Pl. 1, fig. 1.)

2. "A fragment of the bone of the same animal, apparently a part of the coracoid, (fig. 2.)

3. "A portion of what appears to be one of the bones of the auricular digit, from a Chalk-pit at Halling, (fig. 3.)

4. "A portion of a similar bone, from the same locality as No. 1, (fig. 4.)

5. "The head of a long bone, probably the tibia, belonging to the same animal as the head, No. 1, (fig. 5.)

6. "A more perfect bone of the same description, not from the same animal, but found at Halling," (fig. 6.)

In a subsequent communication, dated December 1845, Mr. Bowerbank states, with regard to the specimens, Nos. 5 and 6, which he supposed to be parts of a tibia, that "on a more careful comparison with the figures of *Pterodactylus* by Goldfuss, I am inclined to believe they are more likely to be portions of the ulna."

* I would request the reader who may be desirous to exercise an independent judgement on such facts as have been published on this point, to compare, for example, some of the cells figured by Mr. Bowerbank, in Pl. i, fig. 9, of the 'Quarterly Journal of the Geological Society,' vol. iv, as being those of the bone of a bird, with some of the wider cells, fig. 1, of the same plate, as being those of the bone of a Pterodactyle; and contrast the want of a parallelism in the cells of the Wealden bone, fig. 9, with the parallelism of the long axes of the cells in the bone of the Albatross, fig. 3.

† See the Note, ante, p. 80.

With respect to the long bone, figured in the present work at '*Pterosauria,*' Pl. 6, fig. 11, comparing it with that figured in *ib.*, Pl. 4, fig. 4, Mr. Bowerbank writes:—

"Although the two specimens differ greatly in size, there is so strong a resemblance between them in the form and angularity of the shaft, and in the comparative substance of the bony structure, as to render it exceedingly probable that they belong to the same class of animals;" and he concludes by remarking that "if the part of the head in my possession (see fig. 1), be supposed similar in its proportions to that of *Pterodactylus crassirostris,*—and there appears but little difference in that respect,—it would indicate an animal of comparatively enormous size. The length of the head, from the tip of the nose to the basal extremity of the skull of *P. crassirostris*, is about $4\frac{5}{8}$ inches, while my specimen would be, as nearly as can be estimated, $9\frac{1}{8}$ inches. According to the restoration of the animal by Goldfuss, *P. crassirostris* would measure, as nearly as possible, three feet from tip to tip of the wings, and it is probable that the species now described would measure at least six feet from one extremity of the expanded wings to the other; but if it should hereafter prove, that the bone described and figured by Professor Owen belongs to a Pterodactyle, the probable expansion of the wings would reach to at least eight or nine feet. Under these circumstances, I propose that the species described above shall be designated *Pterodactylus giganteus,*" (p. 8.)

In a subsequent Memoir, read June 9th, 1847, and published in the 'Quarterly Journal of the Geological Society,' February, 1848, Mr. Bowerbank gives figures of the "bone-cells" from the jaw of a *Pterodactyle* (Pl. i, fig. 1), from the shaft of the bone in question (ib., fig. 2), and from the femur of a recent Albatross (ib., fig. 13), in corroboration of the required proof; and he adds:—"Fortunately the two fine specimens from the rich collection of Mrs. Smith, of Tonbridge Wells, represented by fig. 1, Pl. ii, in a great measure justify this conclusion, and in the bone *a*, which is apparently the corresponding bone to the one represented by fig. 1 in Professor Owen's Paper, the head is very nearly in a perfect state of preservation," (Op. cit., p. 5.) Mr. Bowerbank, in his explanation of Pl. ii, describes the two specimens above mentioned, as:—"Fig. 1. Radius and ulna of *Pterodactylus giganteus*, in the Cabinet of Mrs. Smith, of Tunbridge Wells," (Tom. cit., p. 10, '*Pterosauria,*' Pl. 4, fig. 5, of the present work.) He proceeds to state, "there are two other similar bones imbedded side by side in the Collection of Mr. Charles, of Maidstone, of still greater dimensions than those from the Cabinet of Mrs. Smith," and he assigns his grounds for the conclusion, that "the animal to which such bones belonged could, therefore, have scarcely measured less than fifteen or sixteen feet from tip to tip of its expanded wings." These bones are represented in '*Pterosauria,*' Pl. 4, of the present Work.

The Committee of the British Association, for the Reform and Regulation of Zoological Nomenclature, amongst other excellent rules, have determined, that:—

"Names not clearly defined may be changed. Unless a species or group is

intelligibly defined when the name is given, it cannot be recognised by others, and the signification of the name is consequently lost. Two things are necessary before a Zoological term can acquire any authority, viz. *definition* and *publication.* Definition properly implies a distinct exposition of essential characters, and in all cases we conceive this to be indispensable.*

Now with regard to the *Pterodactylus giganteus,* I always understood Mr. Bowerbank to apply the term to the species to which the long wing-bone first described by me might appertain, under the circumstances of its being proved to belong to a Pterodactyle, and my belief in this definition of his species was confirmed by the fact of his subsequently figuring the two similar and equal-sized bones in the 'Quarterly Journal of the Geological Society,' Vol. IV, pl. 2, fig. 1, (Proceedings of the Society for June 9th, 1847,) as the "radius and ulna of *Pterodactylus giganteus.*" So far as a species can be intelligibly defined by figures, that to which the term *giganteus* was, in 1845, provisionally, and in 1847 absolutely applied, seemed to be clearly enough pointed out by the Plate 2, in the Work above cited. But with the large bones appropriately designated by the term *giganteus,* some part of a smaller *Pterodactyle,* including the portions of jaws first announcing the genus in the Chalk, had been associated under the same name. Supposing those bones to have belonged to a young individual of the *Pterodactylus giganteus,* no difficulty or confusion would arise. After instituting, however, a rigid comparison of these specimens, I was compelled to arrive at the conclusion that the parts figured by Mr. Bowerbank, in Plate 1, figs. 1 and 2, of Vol. II of the 'Quarterly Geological Journal,' and the parts figured in Plate 2, figs. 1 *a* and *b* of Vol. IV, of the same Journal, both assigned by Mr. Bowerbank to the *Pterodactylus giganteus,* belonged to two distinct species. The portions of the scapula and coracoid of the Pterodactyle (Pl. 1, fig. 2, vol. ii, op. cit.) indicates, by its complete anchylosis, that it has not been part of a young individual of the species to which the large antibrachial bones (Pl. 2, fig. 1, *a* and *b,* vol. iv, op. cit.) belonged, although it might well appertain to the species to which the jaws (Pl. 1, fig. 1, vol. ii,) belonged. Two species of Pterodactyle were plainly indicated, as I have shown in the Work by my lamented friend, Mr. Dixon, 'On the Tertiary and Cretaceous Deposits of Sussex,' 4to, p. 402. The same name could not be retained for both, and it was in obedience to this necessity, and not with any idea of detracting an iota from the merit of Mr. Bowerbank's original announcement of the existence of a Pterodactyle in the Chalk, that I proposed the name of *conirostris* for the smaller species, then for the first time distinctly defined and distinguished from the larger remains, to which the name *giganteus* had also been given by Mr. Bowerbank. I proposed the name, moreover, provisionally, and with submission to the Committee for the Reform of Zoological Nomenclature, according to whose rules I believed myself to have been guided.

* See their 'Report,' Trans. of the British Association for 1842, 113.

As, however, I have no personal feeling with regard to mere names, I shall apply to the specimens of the jaws of the Pterodactyles, described in the present Work, the names by which Mr. Bowerbank first made those parts known to Geologists, and before entering upon their descriptions shall premise a few remarks on the Pterodactyles in general.

The Order *Pterosauria* includes species of flying reptiles, so modified in regard to the structure and proportions of the skull, the disposition of the teeth, and the development of the tail, as to be referable, even according to the partial knowledge we now possess of this once extensive group, to different genera.

M. von Meyer, *e.g.*, primarily divides the Order into :—

A. Diarthri. With a two-jointed wing-finger.
Ex. *Pterodactylus* (*Ornithopterus*) *Lavateri.*

B. Tetrarthri. With a four-jointed wing-finger.
Ex. All the other known species of the Order.

These again are subdivided into :—

1. *Dentirostres.* Jaws armed with teeth to their ends: a bony sclerotic ring: scapula and coracoid not confluent with one another:* a short moveable tail.
Ex. *Pterodactylus* proper.

2. *Subulirostres.* Jaws with their ends produced into an edentulous point, probably sheathed with horn: no bony sclerotic: scapula and coracoid confluent: a long and stiff tail.
Ex. *Pterodactylus* (*Ramphorhynchus*) *Gemmingi.*†

The extremity of the upper jaw of the *Pterodactylus Cuvieri*, Bowerbank, is sufficiently perfect to demonstrate that it had a pair of approximated alveoli close to its termination, and we may, therefore, refer it to the Dentirostral division.

In this division, however, there are species which present such different proportions of the beak, accompanied by differences in the relative extent of the dental series, as would, without doubt, lead to their allocation in distinct genera, were they the living or recent subjects of the modern Erpetologist. In the *Pterodactylus longirostris*, the first species discovered, and made known by Collini in 1784,‡ the jaws are of extreme length and tenuity, and the alveoli of the upper jaw do not extend so

* The condition of the scapular arch in the *P. giganteus*, Bow., *P. conirostris*, Mihi, demonstrates the fallacy of this character.

† Palæontographica, Heft I, 4to, 1846, p. 19.

‡ Acta Academiæ Theodoro-Palatinæ, v, p. 58, Tab. v.

far back as the nostril, '*Pterosauria,*' Pl. 1, fig. 1. In the *Pterodactylus crassirostris**, (ib. fig. 2,) on the other hand, the jaws are short, thick and obtusely terminated; and the alveoli of the upper jaw reach as far back as the middle of the cavity which intervenes between the nostril and the orbit, and which Goldfuss terms the "cavitas ntiermedia."

In the solid or imperforate part of the upper jaw anterior to the nostril the *Pterodactylus longirostris* has twelve long subequal teeth, followed by a few of smaller size: the same part of the jaw in the *Pter. crassirostris* has but six teeth, of which the first four are close together at the end of the jaw, and the first three shorter than the rest. The "cavitas intermedia" in *P. longirostris* is much smaller than the nostril: in the *P. crassirostris* it is larger than the nostril. Were these two species of dentirostral *Pterosauria* to be taken, as by the modern Erpetologist they assuredly would, to be types of two distinct genera, the name *Pterodactylus* should be retained for the longirostral species, as including the first-discovered specimen and type of the genus; and the crassirostral species should be grouped together under some other generic name.

PTERODACTYLUS CUVIERI, *Bowerbank.* '*Pterosauria,*' Plate 3, figs. 1—7; Plate 4, figs. 1—3.

'Proceedings of the Zoological Society,' January 14th, 1851.

The specimen of gigantic Pterodactyle, exhibited and so named by Mr. Bowerbank at the meeting of the Zoological Society, January 14th, 1851, and which he has confided to me for description in the present Monograph, consists of the solid anterior end, *i. e.*, of the imperforate continuous bony walls, of a jaw, compressed, and decreasing in depth, at first rapidly, then more gradually, to an obtusely pointed extremity. As the symphysis of the lower jaw is long and the original joint obliterated, and its depth somewhat rapidly increased by the development of its lower and back part into a kind of ridge in some smaller Pterodactyles, the present specimen, so far as these characters go, might be referred to the lower jaw, and its relatively inferior depth to the upper jaw in the *Pter. giganteus*, would seem to lead to that conclusion. But the present is plainly a species which has a relatively longer and more slender snout, and the convex curve formed by the alveolar border, slight as it is, decides it to be part of the upper jaw. The lower jaw, moreover, might be expected by the analogy of the smaller Pterodactyles to be flatter or less acute below the end of the symphysis.

The specimen of *Pterodactylus Cuvieri* consists of the anterior extremity of the upper jaw of seven inches in extent, without any trace of the nasal or any other

* Goldfuss, Beiträge zur Kenntniss Verschiedener Reptilien der Vorwelt, 4to, 1831, sec. i, Tabs. vii, viii, ix.

natural perforation of its upper or lateral parietes, and corresponds with the parts marked *a*, *b*, Pl. 1, figs. 1 and 2. From the number of teeth contained in this part, the *Pter. Cuvieri* presents a much closer resemblance to the *Pter. longirostris*, (ib., fig. 1,) than to the *Pter. crassirostris*, (ib., fig. 2;) and, if the entire skull were restored according to the proportions of the *Pter. longirostris*, it would be twenty-eight inches in length.

But nature seems never to retain the same proportions in species that differ materially in bulk. The great Diprotodon, with the dental and cranial characters of a Kangaroo, does not retain the same length of hinder limbs as its living homologue; the laws of gravity forbid the saltatory mode of locomotion to a Herbivore of the bulk of a Rhinoceros; and accordingly, whilst the hind legs are shortened, the fore limbs are lengthened, and both are made more robust in the Diprotodon than in the Kangaroo. The change of proportions of the limbs of the Sloths is equally striking in those extinct species which were too bulky to climb: *e. g.*, the Megatherium and Mylodon. We may therefore infer, with a high degree of probability, when a longirostral Pterodactyle much surpassed in bulk the species so called "par excellence," that the same proportions were not maintained in the length of the jaws, and that the species to which the fine fragment, (Pl. 3, fig. 1,) belonged, far as it has exceeded our previous ideas of the bulk of a flying reptile, did not sustain and carry through the air a head of 2 feet 4 inches in length, or double the size of that of the Pelican. We see, in fact, that the size of the teeth was not increased in the ratio of that of the jaws.

Although the fractured hinder part of the jaw shows no trace of the commencement of the wide nasal aperture, there is a plain indication that the jaws were less prolonged than in the *Pt. longirostris*, in the more rapid increase of the depth of the jaw. Opposite the ninth tooth, *e. g.*, the depth of the jaw equals two fifths of the length of the jaw in advance of that tooth, whilst in the *Pt. longirostris* it is only two sevenths. The contour of the upper border of the jaw in the *Pterodactylus Cuvieri* differs from that in both the *Pt. longirostris*, *Pt. crassirostris*, and *Pt. Gemmingi*, in sinking more suddenly opposite the ninth, eighth, and seventh teeth, than along the more advanced part of the jaw—a character which, while it affords a good specific distinction from any of those species, indicates the hinder parts of the head, that are wanting in the present specimens, to have been shorter, but relatively much deeper, than in the *Pt. longirostris*.

The first pair of alveoli (figs. 1 and 4, *a*) almost meet at the anterior extremity of the jaw, (Pl. 3, fig. 3,) and their outlet is directed obliquely forwards and downwards; the obtuse end of the premaxillary above those alveoli is about two lines across. The palate, (ib., fig. 4,) quickly expands to a width of three lines between the second alveoli; then to a width of four lines between the fourth alveoli; and more gradually, after the ninth alveoli, to a width of six lines between the eleventh alveoli, *a'*: here the palate appears to have been slightly crushed; but in the rest of its extent it

presents its natural form, being traversed longitudinally by a moderate median ridge, on each side of which it is slightly concave transversely. It is perforated by a few small irregular vascular foramina; but the bony roof of the mouth is continued for an extent of six inches without any trace of its interruption by the naso-palatal aperture. There are no orifices on the inner side of the alveoli: the successional teeth, as will be presently shown, emerge as in the Crocodile, from the old sockets, and not as in certain Mammals and Fishes, by foramina distinct from them. The second and third alveoli are the largest; the fourth, fifth, and sixth the smallest, yet they are more than half the size of the foregoing; with which the rest are nearly equal. The outlets of the alveoli are elliptical, and they form prominences at the side of the jaw, or rather the jaw there sinks gently in between the alveoli, and is continued into the bony palate, without any ridge, the vertical wall bending round to form the horizontal plate. The greatest breadth of the under surface of the jaw, taken from the outside of the alveoli, varies only from seven lines across the third pair to nine lines across the eleventh pair of alveoli; and from this narrow base the sides of the jaw converge with a slight convexity outwards at the anterior half of the fragment, but are almost plane at the deeper posterior half, where they seem to have met at an acute superior ridge; indeed, such a ridge is continued to within an inch of the fore part of the jaw, where the upper border becomes more obtuse.

The whole portion of the jaw consists of one uninterrupted bone—the premaxillary; the delicate crust of osseous substance, as thin as paper, is traversed by many irregular cracks and fissures, but there is no recognizable suture marking off the limits of a maxillary or nasal bone. The bone offers to the naked eye a fine fibrous structure, so fine as to produce almost a silken aspect: the fibres or striæ being longitudinal, and impressed at intervals of from two to six lines by small vascular foramina.

The first socket on the right side contains a young tooth which protrudes about a third of an inch obliquely downwards and forwards, (fig. 1, *a*:) the fifth socket on the right side and the eighth on the left contain the germ of a younger tooth, the point of which does not protrude beyond the socket; it lies close to the inner wall of the socket of the old tooth, from which it would have emerged, as in the Crocodile. Two fully developed teeth, (figs. 5 and 6,) are preserved in the same block of chalk with the jaw. One of these is 1 inch 4 lines in length, sabre-shaped, subcompressed, slightly bent, and gradually diminishing in breadth from the widely-open base to the apex: this part is broken off in both specimens, showing the crown to be composed of a compact hard dentine, sheathed by a thin coat of shining enamel: about 9 lines of the basal part of the present tooth, (fig. 5,) is coated by a thin layer of cement. The enamel is marked by extremely fine longitudinal ridges, with an irregular or thready course, of unequal length and with wide intervals, as shown in the magnified view, (fig. 7.) The second, (fig. 6,) is a somewhat smaller tooth; having the same structure.

The unique specimen above described was obtained from the Burham Chalk-pit, Kent, and forms part of the fine Collection of James S. Bowerbank, Esq., F.R.S.

PTERODACTYLUS GIGANTEUS, *Bowerbank.* '*Pterosauria,*' Plate 6.

PTERODACTYLUS GIGANTEUS. *Bowerbank.* Proceedings of the Geological Society, May 14, 1845; in the 'Quarterly Journal of the Geological Society,' February, 1846.

— CONIROSTRIS. *Owen.* Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex,' 4to, p. 401, T. XXXVIII.

This specimen consists of the upper jaw, as far as the commencement of the nostril, (Pl. 6, fig. 2, *n*,) with the corresponding part of the lower jaw. The upper jaw is a subcompressed, three-sided cone, with a more obtuse apex than in *Pterodactylus Cuvieri*, and more rapidly and regularly increasing in depth as it approaches the nostrils, the sides converging at an acute angle as they ascend from the alveolar border, arching over the apex of the jaw, but meeting within an inch from this part at a ridge, which is rather more obtuse than that in *Pt. Cuvieri*, and formed at a somewhat less acute angle, (figs. 3 and 4.) The surface of the bone appears naturally to have been less even or level than in the larger species, and the thin osseous plate is similarly fissured and cracked. The part appears, however, to have suffered little compression; the palate, where it is exposed at the back part of the jaw, being entire, and presenting a concave longitudinal channel on each side of a prominent median ridge: its breadth opposite the ninth alveolus is 8 lines; the depth of the jaw at that part being 14 lines; the breadth of the base of the jaw, there, outside the alveoli, is 11 lines. The sides of the jaw are plane, but sink in a little between the alveoli, where they become continuous with the palatal surface. The alveolar border of the jaw is slightly convex lengthwise along its anterior third, and is continued straight along the rest of its extent. There are ten pairs of alveoli in the part of the upper jaw anterior to the bony nostril, the alveoli being separated by intervals about equal to their own diameter. In the *Pt. Cuvieri* there are at least twelve pairs of alveoli anterior to the nostril, and there may have been more, as there are in the *Pt. longirostris.* In the *Pt. crassirostris* there are only six pairs of alveoli in the corresponding part of the upper-jaw, and the fourth, fifth, and sixth, are separated by intervals of thrice the diameter of the alveolus.

Such characters as these place in a strong light the specific distinctions of the *Pterodactyli* compared. The species under consideration exemplifies in the Cretaceous epoch the crassirostral group of the older secondary *Pterosauria*, as the gigantic *Pt. compressirostris* does the longirostral group; the *Pt. Cuvieri* approaches nearer a middle term between the two types of the groups in question. The length of the jaw anterior to the nostril in the *Pt. crassirostris*, described by Goldfuss,* is 13 lines,

* Nova Acta Acad. Nat. Cur., tom. xv, pt. i, p. 63. (See Plate 1, fig. 2.)

that of the *Pt. giganteus* is 2 inches 3 lines; the total length of the head of the *Pt. crassirostris* is 4 inches 8 lines, that in the *Pt. giganteus*, restored on the same scale, would be 9 inches, and the proportions on which this calculation is made are much more likely to have been maintained, than those of the *Pt. longirostris* in reference to the more gigantic *Pt. Cuvieri;* but the teeth are absolutely shorter, and relatively much smaller, than in the *Pt. crassirostris.*

The lower jaw, fig. 5, has an obtuse rounded termination anteriorly like the upper one, fig.4, but is a little narrower there, and is flatter, its under part being less convex than the corresponding exposed part of the upper jaw is above: the median inferior ridge behind this part is more suddenly developed than that upon the upper jaw, and the progressively deepening sides of the lower jaw are bent inwards before they form the ridge, being convex near the alveoli, and becoming concave at the base of the ridge, in the transverse direction: and this modification does not appear to be the result of accidental pressure. The solid or confluent symphysis has an extent of more than 2 inches, but the bone is too much broken away at its back part to determine its precise extent: it is evident, however, that the rami diverging from it were of less vertical extent than the ridged part of the symphysis from which they diverge, and this character is also shown in the lower jaw of the *Pt. longirostris*, and *Pt. Gemmingi.* On the right side of the lower jaw, which is best preserved, there are nine alveoli, and part of a tenth, corresponding in size and spacing with those above. The inner alveolar wall extends so far inwards, horizontally, that if discovered alone, it might well be mistaken for the palatal plate of an upper jaw. It is not united with that of the opposite side to an extent corresponding with the bony palate above; but to what extent the symphysis of the jaw is continued backwards, the specimen does not allow to be precisely determined. This broad inner alveolar plate of the lower jaw is slightly concave transversely, forming a wide longitudinal channel about two lines and a half in breadth along the inner side of the alveolar border: to the extent to which it may be united to the opposite plate, a median longitudinal ridge will be formed dividing the two channels; and presenting a structure closely corresponding with that of the palate above.

The teeth are preserved, in situ, in some of the alveoli, of both the upper and lower jaws. The enamelled crown is a less elongated and narrow cone than in either the *Pt. Cuvieri*, or the *Pt. crassirostris*, and it is less compressed; it does not exceed one line and a half in length. The fang is longer, and after a slight expansion maintains the same diameter, or contracts a little towards its basal termination. The smooth polished coronal enamel shows the same extremely fine raised striæ, with an irregular course and wide intervals, as in the teeth of *Pt. Cuvieri.* The basal cement has a more irregular external surface. The fractured tooth in the sixth alveolus of the left side shows well the form of the transverse section at the base of the crown, and the proportional size of the pulp-cavity. This, as usual, is occupied by a sparkling

siliceous spath. I am not at present aware of any species of Pterodactyle in which the teeth are so short and thick as in the *Pt. giganteus*, (see the magnified view, fig. 6.) Those figured in Pl 27, Vol. iii., 2d Series, of the 'Geological Transactions,' on the supposition that they might belong to the Pterodactyle, appertain to a species of Fish. The point of a successional tooth projects from the fore part of the ninth socket on the right side of the upper jaw, from which its predecessor has fallen; proving, as in the larger species, that the crowns of the successional teeth do not emerge, as Cuvier surmised to be the case in *Pt. longirostris*,* from a distinct orifice on the inner side of the socket of the old tooth, as in the Mammalia.

The substance of the osseous walls of the above-described portions of jaws is as thin and delicate as in the foregoing species: it does not present the same fine longitudinally striated surface as in the *Pt. Cuvieri;* but it is similarly perforated by numerous minute vascular foramina, which are largest and most abundant near the alveolar border at the fore part of the jaw.

The unique specimen above described was discovered in the Burham Chalk-pit, Kent, and is in the Collection of James Scott Bowerbank, Esq., F.R.S.

Scapular Arch and Bones of the Extremities of the Pterodactylus giganteus, *Bowerbank.* '*Pterosauria,*' Pl. 6, figs. 7, 8, 9, 10—13.

Perhaps no part of the skeleton of the Pterodactyle more closely resembles in form that of the bird, than the scapular arch: and in no specimen has this arch been better preserved than in the *Pterodactylus macronyx*.† The scapula is shown in those specimens to be long, sabre-shaped, and to form a moiety of the articular concavity for the head of the humerus, and the coracoid to be stronger, straighter, and shorter than the scapula, and with a subbifid protuberance near the articular surface for the humerus: the opposite end of the coracoid terminates by a rather oblique truncation, but without expanding: both the elements of the arch are anchylosed together, where they meet at rather an acute angle to form the shoulder-joint. In the *Pt. crassirostris*‡ the two bones appear not to have been anchylosed, the more slender and slightly curved bone, 17, in Prof. Goldfuss's plate, is called the coracoid, the stronger and straighter one, 16, the scapula: but this determination seems to have been based upon the crushed specimen, in which there has been sufficient displacement of parts to render it very probable that the scapula and coracoid have suffered some change of position: the fore part of 17, which I believe to be the scapula, shows a tuberosity near the articular end, which forms an angle between that and the shaft of the bone: the coracoid, 16,

* Ossemens Fossiles, tom. v, pt. ii, pp. 364, 367.

† See Dr. Buckland's Memoir, 'Geological Transactions,' 2d Series, vol. iii, pl. xxvii, X, 9; and Von Meyer, in the 'Nova Acta Acad. Nat. Curios. tom. xv, pt. ii, Tab. lx, fig. 8.

‡ Goldfuss, *ut supra*, T. VII, 16, 17.

exhibits a stronger tuberosity near the same part; the sternal end of this bone is slightly expanded and rounded. The length of the scapula is rather more than one-third of that of the entire skull.

In the same block of chalk as that which contained the fore part of the jaws of the *Pt. giganteus*, is preserved the confluent extremities of the right scapula and coracoid, one third larger than the corresponding parts in the *Pt. crassirostris*, and one-fourth larger than those in the *Pt. macronyx*. The portion of scapula, (Pl. 6, figs. 7 and 8, 51,) includes thirteen lines of the humeral end of that bone; the fractured part of the body showing that part to be subcompressed, with the side next the ribs slightly concave, the opposite side convex; the long diameter of this section of the bone is 3 lines; its short diameter 1 line; it expands as it approaches the shoulder joint, and developes an obtuse oval tubercle, *a*, from its upper and inner border about 4 lines from the articular end; a low acromial ridge is extended from the outer side of the bone, from near the origin of the tubercle, to the outer and fore part of the glenoid cavity: the inner and posterior border is expanded into a third ridge which joins a corresponding one from the same part of the coracoid. Of this bone, 52, about ten lines is preserved: the transverse section exposed at the fractured end is oval, and measures 3½ lines by 2 lines; the expansion of the bone to form the shoulder-joint is rapid. Besides the ridge sent off from the inner and back part to join the one above mentioned from the scapula, there is a much stronger process, *c*, developed from the under and fore part of the coracoid, as in that of the *Pt. macronyx*, between which and the glenoid surface the bone is perforated by a narrow canal, the inner outlet of which is just above the inner ridge. If we carry forwards the two straight lines respectively parallel with the outer borders of the scapula and coracoid, they will meet at an angle somewhat less acute than those in the *Pt. macronyx*. By a trace of the original suture we may see that the coracoid has formed about two thirds of the glenoid cavity, (fig. 7, *g*:) the long diameter of that cavity measures 6 lines, its short diameter 3½ lines; in the direction of which it is flat above and slightly convex below; being concave only in the direction of its long axis; its contour is reniform, the convex border being extended upon the acromial ridge. The long diameter of the glenoid cavity in the *Pt. macronyx* measures 4 lines; and the absence of the tuberosity on the scapula makes that end of the bone relatively more feeble than in the present instance. As the parts are fully one third larger than those in the *Pt. crassirostris*, we may estimate the skull of the present species according to the proportions of the scapula to the skull in *Pt. crassirostris*, as having been about 7 inches in length. Both the scapula and coracoid are hollow, the cavity being surrounded by a very thin compact wall, and being subdivided by a few much thinner plates.

There is a fragment of a bone, (Pl. 6, fig. 9,) in the same block of chalk, which, from its rapid expansion, I am induced to suspect to be part of the sternum: its thickest part presents a coarse cancellous structure: from this part it expands into a thin plate, of which, however, not enough remains to indicate its original form.

Several portions of long bones figured in Pl. 6, may well belong, by their size, to the same species as the portion of jaws, figs. 1 and 2, in the same plate: two of them, figs. 11 and 12, are from a different locality, Halling pit, but from the same formation—the Middle Chalk of Kent. As all these fragments, however, consist only of the simple hollow shaft, I shall proceed with the description of the better preserved specimens from the chalk which are referable to the genus *Pterodactylus*.

PTERODACTYLUS COMPRESSIROSTRIS, *Owen.* '*Pterosauria,*' Plate 3, figs. 8, 9, and 10.

This species is represented by two portions of the upper jaw, obtained from the Middle Chalk of Kent, the hinder and larger of which includes the beginning of the external nostril, (fig. 8, *n*.) The depth of the jaw at this part is 14 lines, whence it gradually decreases, so as, at a distance of 3 inches in advance of this, to present a depth of 10 lines, indicating a jaw as long and slender as in the *Pterodactylus longirostris*, (Pl. 1, fig. 1,) supposing the same degree of convergence of the straight outlines of the upper and alveolar borders of the jaw to have been preserved to its anterior end: that this was actually the case is rendered most probable by the proportions of the smaller anterior part of the jaw, (Pl. 3, fig. 8′ and 9′,) obtained from the same pit, if not from the same block of Chalk, and which, with a vertical depth of 7 lines at its hinder part, decreases to one of 6 lines in an extent of $1\frac{1}{2}$ inch in advance of that part. The sides of the jaw as they rise from the alveolar border incline a little outwards before they converge to meet at the upper border. This gives a very narrow ovoid section at the fore part of the larger fragment (fig. 9*), the greatest diameter, at its lower half, being 4 lines, and the sides meeting above at a slightly obtuse ridge. This very gradually widens as the jaw recedes backwards, where the entireness of the walls of the smoothly convex upper part of the jaw proves that the narrowness of that part is not due to accidental crushing. Had that been the case, the thin parietes arching above from one side to the other would have been cracked. The only evidence of the compression to which the deep sides of the jaw have been subject is seen in the bending in of the wall above the alveoli, close to the upper ridge, at the fore part of the fragment, in the crushed state of the palate at that part, and in a slight depression of the left side of the jaw anterior to the nostril.

In an extent of alveolar border of $3\frac{1}{2}$ inches, there are eleven sockets, the anterior one on the right side retaining the fractured base of a tooth: the alveoli are separated by intervals of about one and a half times their own diameter; their outlets are elliptical, and indicate the compressed form of the teeth: they are about 2 lines in long diameter, at the fore part of this fragment, but diminish as they are placed more backwards, the last two being developed beneath the external nostril.

The bony palate is extremely narrow, and presents, in the larger portion, fig. 10, a median smooth convex rising between two longitudinal channels, which are bounded externally by the inner wall of the alveolar borders. There is no trace of a median suture in the longitudinal convexity. The breadth of the palate at the back part of the fragment is 8 lines, at the fore part it has gradually contracted to less than 3 lines, but it is somewhat crushed here, (fig. 10, *a*.) The naso-palatine aperture commences about half a line in advance of the external nostril, 3 inches behind the fore part of the larger portion of the skull: its form and extent, so far as it is preserved, are accurately shown in fig. 10, *p*, and it well exemplifies, in this specimen, the characteristic extent of the imperforate bony palate formed by the long single premaxillary bone in the present order of Saurians.

The fragment from the more advanced part of the jaw, fig. 8, contains five pairs of alveoli, in an extent of 2 inches, these alveoli being rather larger and closer together than in the hinder part of the jaw. Owing to the compression which the present portion has undergone, the orifices of the alveoli are turned outwards; the bony palate being pressed down between the two rows, and showing, probably as the result of that pressure, a median groove between two longitudinal convex ridges; but the bone is entire and imperforate. The form of the upper jaw in the present remarkable species differs widely from that of the two previously described specimens from the Chalk, in its much greater elongation, its greater narrowness, and from the *Pt. Cuvieri,* more especially, in the straight course of the upper border of the jaw, as it gradually converges towards the straight lower border in advancing to the anterior end of the jaw. The alveoli, and consequently the teeth, are relatively smaller in proportion to the depth of the jaw than in the *Pt. Cuvieri,* and are more numerous than in the *Pt. giganteus:* they are, probably, also, more numerous than in the *Pt. Cuvieri;* although, as the whole extent of the jaw anterior to the nostril is not yet known in that species, it would be premature to express a decided opinion on that point. As we may reasonably calculate from the fragments preserved, (Pl. 3, figs. 8 and 8',) that the jaw of the *Pterodactylus compressirostris* extended seven inches in front of the nostril, it could not have contained less than twenty pairs of alveoli, according to the number and arrangement of those in the two portions preserved.

The osseous walls in both portions present the characteristic compactness and extreme thinness of the genus: the fine longitudinal striæ of the outer surface are more continuous than in the *Pt. Cuvieri,* in which they seem to be produced by a succession of fine vascular orifices produced into grooves. The conspicuous vascular orifices are almost all confined to the vicinity of the alveoli in the *Pt. compressirostris.* This species belongs more decidedly than the *Pt. Cuvieri* to the longirostral section of the *Pterosauria:* whether it had an edentulous prolongation of the fore part of the upper and lower jaw, as in the *Pt. Gemmingi,* remains to be proved.

In attempting to form a conception of the total length of the head of the very remarkable species of Pterodactyle, represented by the portions of jaw above described, we should be more justified by their form in adopting the proportions of that of the *Pt. longirostris* than in the case of the *Pt. Cuvieri:* but, allowing that the external nostril may have been of somewhat less extent than in the *Pt. longirostris,* we may still assign a length of from 14 to 16 inches to the skull of the Pterodactyle in question, of which I have attempted an analogical restoration in '*Pterosauria,*' Pl. 1.

It could not have been anticipated that the first three portions of Pterodactylian skull, and almost the only portions that have yet been discovered in the Cretaceous Formations, should have presented such well-marked distinctive characters one from the other as are described and illustrated in the present Work. Such, nevertheless, are the facts; and however improbable it may appear, on the doctrine of chances, to those not conversant with the fixed relations of osteological and dental characters, that the three corresponding parts of three Pterodactyles, for the first time discovered, should be appropriated to three distinct species, I have no other alternative, in obedience to the indications of Nature, than to adopt such determination.

The portions of the skull of the *Pterodactylus compressirostris,* like those of the *Pt. Cuvieri* and *Pt. giganteus,* were discovered in the Chalk-pit at Burham, Kent, and are in the Collection of James Scott Bowerbank, Esq., F.R.S., to whose skill is due the exposure of the palatal surface and the left side of the portion of the jaw, figured in Pl. 3, figs. 8 and 10.

LONG BONES OF PTERODACTYLUS CUVIERI. '*Pterosauria,*' Plate 4, figs. 1, 2, and 3.

The bone which, from its size, and from the character of its external surface may be, with most probability, referred to the largest of the above-defined species of Cretaceous Pterodactyles, is that which forms the subject of figures 1, 2, and 3, Pl. 4. It was discovered in the Chalk-pit, at Burham, Kent, and is now in the Collection of J. Toulmin Smith, Esq., of Highgate.

The length of the bone in proportion to its thickness is too great to be compatible with its being the humerus; it indicates it to be either one of the antibrachial bones, or, more probably, from its similarity in shape to the long bones of most frequent occurrence in smaller species, the first or the second phalanx of the elongated wing-finger.

One end of the bone is nearly entire, the other end is wanting, the total length of the specimen being $14\frac{1}{2}$ inches. The longest diameter of the preserved extremity is 2 inches 3 lines, whence the shaft decreases to a diameter, in the same direction, of 1 inch, and then more gradually expands to a diameter of 1 inch 3 lines at the fractured end. The shaft soon assumes a triedral figure, with the angles rounded off, and the breadth of the narrowest side is shown in fig. 3. The contour of the best

preserved end is shown at fig. 2*, where *a* and *b* may give the form and position of natural articular surfaces, but there seems to have been some slight restoration here: *c* is a vacuity where the bone is deficient: the contour of the border of the bone at *a*, fig. 2, which is obviously entire, satisfactorily indicates, however, the concavity of the articular surface as shown at *a*. This, were the bone an ulna or a phalanx of the wing-finger, would determine the end preserved to be a proximal one: but, if the bone were a radius, the concavities *a* and *b* might be adapted to some of the small carpal bones. The presence of a pneumatic foramen, at *p*, figs. 1 and 3, would seem, however, to show the extremity near which it is situated to be a proximal one, and if any trust could be placed in the analogy of the bones of birds, the position of this pneumatic foramen, with the double articular concavity, *a* and *b*, and the three-sided shape of the shaft, would concur in leading to a reference of the bone to the ulna.

The side of the expanded proximal end shown in fig. 2 is slightly convex: that shown in fig. 1 is almost flat: whilst the pneumatic foramen is situated in a deep and narrow concavity or groove which forms the beginning, or the end, of the narrowest of the three sides of the shaft of the bone; but the concavity is speedily changed, as it passes down the shaft, for a convexity, which subsides to a flattened surface at the middle of the shaft, as shown in fig. 2. The broadest side, shown in fig. 2, becomes flattened in the shaft of the bone: the transverse section of which, four inches from the entire end, is shown in fig. 3*, which gives the thickness of the compact osseous walls of the large air-cavity of the shaft: the thickness of these walls is also shown at their fractured borders in figs. 1, 2, and 3; it exceeds, as might be expected, that of the similarly sized pneumatic wing-bones of the gigantic Crane and Pelican. The character of the surface of the bone closely resembles that of the portion of the jaw of the *Pterodactylus Cuvieri*.

Long Bones of Pterodactylus compressirostris. '*Pterosauria*,' Plates 2 and 4, figs. 4 and 5.

In the reference of the long bones from the same locality or division of the Chalk Formations as those from which the jaw-bones of the Pterodactyles have been derived, the chief guide, at present, is the relative size of the parts.

It is not likely that one can err in associating the largest specimens of the wing-bones, such as that above described, with the Pterodactyle with the largest and strongest jaw, especially when we find the same fine furrows and foramina giving a silky appearance to the surface of both.

The smaller specimens seem by their more compact and smooth surface to belong to the smaller species; but they may have been parts of smaller or younger individuals of the larger species: this, however, is the least likely of the conjectures to which, in the detached and fragmentary condition of the parts of the skeletons of these huge-winged

reptiles that have hitherto reached us, we are reduced in the attempts at their restoration.

In a mass of white chalk, about thirteen inches in length, in the collection of Thomas Charles, Esq., are imbedded three portions of long-bones; one of these (Pl. 2, fig. 1,) is seven inches in length, and shows a crushed articular extremity, 2 inches 2 lines in diameter, the shaft at the opposite fractured extremity being 1 inch 3 lines in the longest diameter; a second fragment (Pl. 2, fig. 3,) is $6\frac{1}{2}$ inches in length, with a diameter of 8 lines at its smaller fractured end, and a diameter of 1 inch 3 lines at its larger fractured end, to which it gradually expands; the third portion (fig. 1, *a a*,) may be a part of the same bone, as fig. 3; it extends from close to the smaller fractured end of that bone in the opposite direction, but in the same line, gradually expanding; its length being 5 inches, and its diameter at the broader fractured end about one inch.

The largest portion of bone (Pl. 2, fig. 1,) presents at its expanded end two surfaces, divided by a strong ridge, about one inch in length, the prominent summit of which has been broken away. One of the surfaces is three times the breadth of the other and is slightly concave transversely, becoming flat as it recedes from the ridge to the tuberosity which terminates the end of the bone furthest from the ridge. This tuberosity is subcompressed; many linear impressions, indicative of the insertion of an aponeurosis or ligament, radiate from it upon the flat surface of the bone: a slight concavity on the end of the bone bounds the tuberosity opposite to the ridge; the rest of that end, including the articular surface, is, as usual, destroyed. The second surface is flat, and slopes away at an open angle from the broader one. Below these surfaces, the outer layer of the thin, compact, osseous wall, has scaled off, and the shaft has been fractured across obliquely, about three inches from the expanded end. The thin wall of the shaft is then continued in broken portions for about three inches lower down, and the rest of the shaft is represented by the cast of its interior in the white chalk. This cast shows, on the surface which was next the bone, several impressions, chiefly in an oblique direction, and nearly parallel with one another; they are shallow and smoothly rounded at the bottom, and may be presumed to have been left by ridges on the inner surface of the medullary or pneumatic cavity of the bone: blood-vessels merely would have perished before the chalk, which must have been introduced into the cavities of these bones in a soft state, could have hardened sufficiently to retain the impression.

With regard to the two other fragments, which are probably parts of an antibrachial bone of the same wing, there is even less character to be obtained from an articular end than in the preceding fragment. On the supposition that the two portions belong to the same bone, it must have been upwards of fourteen inches in length. In the portion, Pl. 2, fig. 3, a part of the inner surface of the thin compact wall of the medullary cavity of the bone is exposed: its smoothness is broken by feeble linear elevations, which are reticularly disposed: it is in appearance very

similar to what may be seen on the smooth inner surface of an air-bone in a large flying-bird, the Pelican or Adjutant Crane, for example: but it is not peculiar to bird's bones. I find something of the same character on the smooth inner surface of the medullary cavity of the tibia of a young gavial, and on the same inner surface in a femur of a lion; only here there are minute vascular perforations leading to the thick parietes of the bone, which do not exist in the bird's bone, or in the fossil in question. The enlarged end of the portion of bone, Pl. 2, fig. 3, shows evidence of a light open cancellous structure.

The thickness of the compact wall of the large medullary cavity does not exceed half a line, as is shown in fig. 3; it is a little thicker towards the smaller end of the large bone, figure 1. In neither case does it exceed the thickness of the shaft of the humerus or ulna of the Pelican.

The transverse section of the smaller end of the portion of the largest bone, Pl. 2, fig. 1, is a moderately long ellipse, rather more pointed at one end than at the other, indicating an approach to something like a ridge or angle along the corresponding side of the bone. The transverse section of the slender part of the smaller fragments also gives a long ellipse. Neither of the bones show the three-sided figure which characterises the long bone ascribed to the *Pterodactylus Cuvieri*, Pl. 4, figs. 1—3, or that, fig. 4 of the same plate, originally figured in the 'Geological Transactions,' 2d series, vol. vi, Pl. 39, fig. 1.

The bone with which the larger portion, fig. 1, Pl. 2, is best comparable, is the humerus, of which it may be the distal portion; but much is wanted in order to attain to a satisfactory determination of it.

On the supposition that it is part of the humerus, and that the other two portions on the same block of chalk are parts of one bone, this bone may be the shaft of the radius.

Pl. 4, fig. 5, represents, of the natural size, in the same block of chalk, portions of two longitudinally juxtaposed bones, of nearly equal size, and of similar form, and in this respect resembling the radius and ulna of the Pterodactyle, as they are shown in the *Pt. longirostris* of Collini and Cuvier,* in the *Pt. medius* of Count Munster,† and in the *Pt. crassirostris* of Goldfuss.‡ Of one of these bones an extent of upwards of nine inches is preserved in three successive portions, in the present specimen. About four inches of the other bone is preserved. Both this and the chief part of the adjoining bone gradually expand to the natural articular end, of which, however, only a small part is preserved in each, showing a shallow smooth concavity; this which is best preserved in the bone, fig. 5*, *d*, obliquely overlaps a small part of the longer bone. The long diameter of the extremity of the shorter portion of bone is one inch five lines; from

* Annales du Museum, t. xiii, pl. 31. † Nova Acta Acad. Nat. Curios., vol. xv, pt. i, T. VI.
‡ Ib., T. VII and VIII, 22, 23.

which the shaft gradually decreases to a diameter of nine lines. The side imbedded in the chalk is convex; that exposed to view is nearly flat; but it is somewhat crushed; the longer portion of the other bone is also too much crushed to give an idea of its natural shape. Like the portions of bone in Pl. 2, these also present a thin wall of compact bone encompassing a very wide medullary or pneumatic cavity; the thickness of the wall equals that of the same part of the ulna of the Pelican, Pl. 5, fig 1.

In the long bone, fig. 4, Pl. 4, the original of the fig. 1, Pl. 39, of the 'Geological Transactions,' 2d series, vol. vi, the natural shape of the bone is better preserved; but, unfortunately, only one small portion of the articular surface is preserved at the expanded end, and this merely exhibits part of a shallow concavity, with a thin well-defined border, fig. 4*, *a*. From this articular end to the opposite fractured end of the shaft, the bone measures twelve inches. The breadth of the expanded end is one inch and a half, whence the shaft gradually diminishes to a diameter of nine lines at its middle part, and more gradually increases to a diameter of eleven lines at the broken end.

The bone is very slightly bent lengthwise at its expanded end; it is straight in the rest of its extent; its shaft is unequally three-sided, with the sides smooth and flat, and the angles rounded off. The compact osseous wall is about the third of a line in thickness, and incloses, as in the other specimens, an uninterrupted wide cavity. One of the sides of the bone equals the extreme breadth of the shaft; a second measures seven lines across, the third five lines; the second side increases in breadth, at the expanded end, in a much greater degree than the third or narrowest side; and this seems to have been indented by a natural fossa, and to have been perforated, at *p*, for the admission of air to the cavity, before terminating at the border of the articular concavity. The true nature of this perforation, which I formerly apprehended might be accidental in the fractured state of that end of the bone, and before the discovery of other specimens, is illustrated by the presence of a similar perforation in the larger sized corresponding bone fig. 1, *p*; and gives additional evidence of the remarkable fact of the agreement of some of the flying-reptiles with birds in the extension of the air-cells into the cavities of the bones.

Pl. 2, fig. 2, is the terminal portion of a long bone, with the articular end again unfortunately destroyed, so as to deprive us of one of the best guides to the determination of the fragment. So much of it as is preserved corresponds pretty closely with the proximal end of the foregoing bone: it is subtriedral, with the angles rounded off; the broadest side is imbedded in the chalk; the expansion of the exposed surface is chiefly due to that of the next broadest side; and the narrowest side, as it approaches the articular end, is impressed by a deep and narrow fossa, in which there is an interruption of the thin walls of the bone in the corresponding position of that, which, in the foregoing specimens, I have called a "foramen pneumaticum." A portion of the bone indicates the extension of a process beyond the articular cavity, which

is a character of the proximal end of the first phalanx of the wing-finger, but no part of the articular surface has been preserved.

A similar portion of the corresponding bone of the opposite wing is figured in Pl. 5, fig. 2, and the more frequent occurrence of long bones with the subtriedral shaft, showing a contraction and deepening of the narrowest of the three sides towards one of the expanded ends of the bone, and the presence of the pneumatic foramen in the groove so formed, would indicate them to be one of those bones that are present in greatest number in the framework of the wing of the Pterodactyle, viz., phalanges of the singularly long and strong wing-finger.

The fragment of the shaft of a bone, with a wide cavity, Pl. 5, fig. 3, shows a different shape from most of the long bones above described; its transverse section is given at fig. 3′; and from its shape, and the presence of a longitudinal ridge at one side of the flatter and probably posterior part of the shaft, I am inclined to regard it as having been part of a femur; it bears the same proportion to the diameter of the humerus, Pl. 2, fig. 1, as the femur of the *Pterodactylus crassirostris* does to the humerus, in the beautiful plates of the Memoir by Goldfuss, above quoted.

The fragments of long bones, with the best preserved articular extremity, are those represented of the natural size in Pl. 5, figs. 4 and 5, the former of which was originally figured in the 'Geological Transactions,' 2d Series, vol. vi, pl. 39, fig. 2, the latter in the 'Quarterly Journal of the Geological Society,' vol. iv, pl. ii, fig. 4.

Both these bones offer the closest resemblance to the trochlear modification of the lower end of the tibia in the bird; and, if we might presume on that analogy, it would be to the same bone in the gigantic Pterodactyle, that we should, also, refer them, with the present indubitable evidence of the existence of volant reptiles of such dimensions in the formation and localities whence the specimens in question have been derived. But it is not likely that a reptile with distinct tarsal bones would have the same modification of the distal end of the tibia as in the bird, which does not possess them.

The specimen which is the subject of fig. 5, in Pl. 5, was obtained by J. Toulmin Smith, Esq. from a chalk-pit near Maidstone, and has not suffered the degree of compression which distorts the specimen, fig. 4, Pl. 5, which was obtained by the Earl of Enniskillen from the same pit. The obliquity of the two parallel, convex, narrow condyles, which I suspected might be the effect of crushing in fig. 4, is shown to be natural in fig. 5; the back part of each condyle is broken away, but their antero-posterior extent is fortunately shown in fig. 4. The shaft is naturally compressed from before backwards, as is shown by the section, fig. 5″, and by the side view fig. 5′. There are two depressions and two rough elevations on the surface of the bone, fig. 5, and between the latter a groove extends longitudinally, as if for the passage of a strong tendon; the vacuity in the thin parietes of the bone above the condyle is, I am assured by Mr. Smith, a natural one, which he himself exposed upon carefully removing

the chalk; and it closely resembles the character of the "foramen pneumaticum" in a bird's bone, but I am not aware of any in that class which is situated on the back part of the distal end of the tibia. On the opposite side of the bone it presents a concavity, which, however, is deepened by the yielding of the thin parietes of the bone at that part.

In the crushed specimen, fig. 4, the convex contour of the condyles bounding the deep trochlea, describes three fourths of a circle, and hitherto not any of the few well-preserved articular ends of the bones of the Pterodactyles have exhibited this structure.

This remarkable trochlear joint may terminate either the femur, or the short and thick metacarpal bone of the wing-finger, from the degree of obliquity of the joint I incline to regard it as part of the latter.

Figures 6 and 7, Pl. 5, exhibit two portions of a long bone of a gigantic Pterodactyle from the Green-sand near Cambridge, the shaft of which repeats the same inequilateral triedral form as that of figs. 1 and 4, in Pl. 4. The smaller fragment of Pterodactylian bone, also from the Green-sand of Cambridge, fig. 8, Pl. 5, indicates, by the strong and broad ridge, that it formed part of the proximal end of a humerus; either of a younger individual, or of a species not larger than that called *Pterodactylus giganteus*, by Mr. Bowerbank, and of which some of the long bones are figured in Pl. 6.

The natural length of the different segments of the wing of the great Pterodactyles of the Chalk may be estimated, according to their proportions in better preserved specimens of the genus, if we can gain approximatively that of any one of the bones, and more especially of the humerus. This I have endeavoured to do, with the following results.

In the *Pterodactylus macronyx*, *Pt. crassirostris*, *Pt. longirostris*, the breadth of the distal end of the humerus equals rather more than one fifth of its length, and according to this proportion, the humerus, assigned to *Pt. compressirostris*, Pl. 2, fig. 1, may be restored, and would give a total length of ten inches and a half.

In the *Pt. macronyx*, the length of the humerus is equal to three fourths of that of the ulna; in *Pt. crassirostris* it nearly equals one half; in the *Pt. longirostris* it equals two thirds of the ulna; in *Pt. longicaudatus* it equals three fifths of the ulna. Taking the mean of these proportions, which is nearly that in the *Pt. longirostris*, we may assign fifteen inches as the probable length of the antibrachial bones of the *Pt. compressirostris*. If the bone, Pl. 4, fig. 1, be the ulna of the *Pt. Cuvieri*, it must have been longer by some inches.

The species of smaller Pterodactyles above cited show a greater difference in the proportions of the metacarpal bone of the wing-finger. In the *Pt. macronyx* this bone is one half the length of the humerus: in the *Pt. longirostris* it is at least of equal length with the humerus; the *Pt. crassirostris* and *Pt. longicaudatus* come nearer the *Pt. macronyx* in the proportions of this bone: we may therefore assign, without hazarding an exaggeration, the length of six inches to both carpus and metacarpus of the *Pt. compressirostris*.

With regard to the first phalanx of the wing-finger, this bone in *Pt. macronyx* is to the humerus as 31 to 26; in the *Pt. crassirostris* it is as 22 to 16; in the *Pt. longirostris* as 17 to 10; in *Pt. longicaudatus* as 2 to 1. In two of the above-cited species it is longer than the ulna, in the other two it is shorter: we shall probably not greatly err if we adopt the mean, and assign an equal length to the first phalanx with the ulna itself in the *Pt. compressirostris*, viz. fifteen inches. In the *Pt. macronyx* the second phalanx of the wing-finger a little exceeds the length of the first: in the other species cited, it is a little shorter; we may assign, therefore, a length of 14 inches to the second phalanx in the *Pt. compressirostris.* Supposing the long bone of the *Pt. Cuvieri* (Pl. 4, fig. 1) to be a phalanx of the wing-finger, it equals the dimensions above assigned to those of the *Pt. compressirostris* in its present mutilated state.

With regard to the proportions of the third phalanx, the *Pt. macronyx* offers a marked difference from the three other species here compared: its length being to that of the first phalanx as 5 to 4, whilst it presents the reverse proportions in the rest. So likewise, with regard to the last slender pointed phalanx of the wing-finger, this exceeds the length of the penultimate phalanx in *Pt. longicaudatus*, but falls short of that length in *Pt. longirostris*, the difference being very small in both cases: the last phalanx is not preserved in the specimen of the *Pt. macronyx*,* nor in that from which Professor Goldfuss has conjecturally restored the *Pt. crassirostris*.†

If we assume the penultimate and last phalanges of the *Pt. compressirostris* to have been of equal length, and restore them according to the proportions of those of the *Pt. longirostris*, we may assign the length of 26 inches to the two bones; but if the proportions of the *Pt. macronyx* were preserved in the gigantic species, the last two phalanges would be 30 inches in length. According to the former restoration the length of the bones of one wing, in a straight line, would be 7 feet 2 inches; according to the latter restoration, 7 feet 6 inches. We may be assured that we are within the bounds of moderation in assigning an expanse of 7 feet to each wing of the smaller of the two great Pterodactyles of the Chalk, and supposing it to have had a breadth of chest from one humeral joint to the other of 1 foot, it would measure 15 feet from the tip of one wing to that of the other, an expanse of pinions rarely equalled, and still more rarely exceeded by the largest Albatross.‡ The *Pterodactylus Cuvieri* was probably upborne on an expanse of wing not less than eighteen feet from tip to tip.

* Geol. Trans., 2d Series, vol. iii, pl. xxvii. † Nova Acta Acad. Nat. Curios., tom. xv, pt. i, Tab. IX.

‡ Latham cites the following testimonies to the extent of the wings of the Albatross:—"Above ten feet, (Foster's Voyage, i, p. 87.) Ten feet two inches, called an enormous size, (Hawkesworth's Cook'. Voy., iii, p. 627.) Eleven feet seven inches, (Parkinson's Voyage, p. 82.) Twelve feet, MS., at Sir Joseph Banks's. One in the Leverian Museum expanded thirteen feet; and Ives mentions one, shot off the Cape of Good Hope, measuring seventeen feet and a half from wing to wing, (See Voyage, p. 5.)" (Latham's History of Birds, vol. x, p. 48, ed., 1824.)

CHAPTER VI.

ORDER. *DINOSAURIA.*

Genus—IGUANODON. '*Dinosauria,*' Plates 1—5.

Mr. W. H. BENSTED, of Maidstone, the proprietor of a stone-quarry of the Shanklin-sand formation, in the close vicinity of that town, had his attention one day, in May 1834, called by his workmen to what they supposed to be petrified wood in some pieces of stone which they had been blasting. He perceived that what they supposed to be wood was fossil bone, and with a zeal and care which have always characterised this estimable man in his endeavours to secure for science any evidence of fossil remains in his quarry, he immediately resorted to the spot. He found that the bore or blast by which these remains were brought to light, had been inserted into the centre of the specimen, (which is figured in '*Dinosauria,*' Plates 1 and 2,) so that the mass of stone containing it had been shattered into many pieces, some of which were blown into the adjoining fields. All these pieces he had carefully collected, and proceeding with equal ardour and success to the removal of the matrix from the fossils, he succeeded after a month's labour in exposing them to view, and in fitting the fragments to their proper places.*

The quarry in which these remains were brought to light consists of many strata, regularly alternating, of compact lime-stone, and of sand more or less loose. Each stratum is of the thickness of from eight inches to twelve or fourteen inches, and the alternation of the two beds is remarkably regular and equal. The bed in which the fossil turtle *Protemys serrata,* described at pp. 169—173 of the present Work, was discovered, lies about fifteen feet below the Iguanodon bed, and is remarkable for the accumulations of the spiculæ of sponges, with which it abounds. Not far below this is the "Atherfield clay," which joins the "Wealden," the junction of the two being scarcely discoverable, owing to the similarity in texture and colour of the two clays.

* In a contemporary notice of this discovery, written with evident knowledge of the facts, and within a month after they occurred, it is stated:—"By the great care bestowed upon them, however, by the very intelligent proprietor of the quarry, Mr. W. H. Bensted, nearly all the detached pieces have been collected, and the various bones carefully cleared from the rock which forms their matrix." (Philosophical Magazine, July, 1834.)

Dr. Mantell, referring, in 1848, to this specimen in his 'Wonders of Geology,' vol. i, p. 427, states:—"The rock was shattered to fragments by the explosion, and the bones were broken into a thousand pieces: but after much labour, I succeeded in uniting the several blocks of stone, and ultimately cleared and repaired the bones, and restored the specimen to its present state." As the specimen was presented to Dr. Mantell, from whom it was purchased, with the rest of his Collection, by the British Museum, we are probably indebted to his skill as well to that of its discoverer for the actual condition in which it may now be studied.

Amongst the portions of the skeleton recovered by Mr. Bensted, were fortunately a portion of one tooth and the cast of a second in the matrix. These were recognised by him as being the teeth of the Iguanodon, which had previously been discovered in the Wealden of Tilgate Forest,* and which had been described by Dr. Mantell in a Paper printed in the 'Philosophical Transactions' for 1825; where that assiduous explorer of the Wealden acknowledges the mode by which he obtained the required information respecting them.

"As these teeth were distinct from any that had previously come under my notice, I felt anxious to submit them to the examination of persons whose knowledge and means of observation were more extensive than my own. I therefore transmitted specimens to some of the most eminent naturalists in this country and on the continent. But although my communications were acknowledged with that candour and liberality which constantly characterise the intercourse of scientific men, yet no light was thrown upon the subject, except by the illustrious Baron Cuvier, whose opinions will best appear by the following extract from the correspondence with which he honoured me:—

"'Ces dents me sont certainement inconnues; elles ne sont point d'un animal carnassier, et cependant je crois qu'elles appartiennent, vu leur peu de complication, leur dentelure sur les bords, et la couche mince d'émail qui les revêt, à l'ordre des reptiles. A l'apparance extérieure on pourrait aussi les prendre pour des dents de poissons analogues aux tetrodons, ou aux diodons: mais leur structure intérieure est forte différente de celles-là. N'aurions-nous pas ici un animal nouveau! un reptile herbivore? et de même qu'actuellement chez les mammifères terrestres, c'est parmi les herbivores que l'on trouve les espèces à plus grande taille, de même aussi chez les reptiles d'autrefois, alors qu'ils étaient les seuls animaux terrestres, les plus grands d'entr'eux ne se seraient-ils point nourris de végétaux? Une partie des grands os que vous possédez appartiendrait à cet animal unique, jusqu'à present, dans son genre. Le temps *con*firmera ou *in*firmera cette idée, puisqu'il est impossible qu'on ne trouve pas un jour une partie de la squelette réunie à des portions de mâchoires portant des dents. C'est ce dernier objet surtout qu'il s'agit de rechercher avec le plus de persévérance.'

"These remarks," Dr. Mantell proceeds to say, "induced me to pursue my investigations with increased assiduity, but hitherto they have not been attended with the desired success, no connected portion of the skeleton having been discovered. Among the specimens lately connected, some, however, were so perfect, that I resolved to avail myself of the obliging offer of Mr. Clift (to whose kindness and liberality I hold myself particularly indebted), to assist me in comparing the fossil teeth with those of the recent Lacertæ in the Museum of the Royal College of Surgeons. The result of this examination proved highly satisfactory, for in an Iguana which Mr. Stutchbury

* "The first specimens of the teeth were found by Mrs. Mantell in the coarse conglomerate of the Forest, in the spring of 1822." (Mantell, 'Geology of the South-East of England,' 8vo, 1833, p. 268.)

had prepared to present to the College, we discovered teeth possessing the form and structure of the fossil specimens." (Phil. Trans., 1825, p. 180.) And he afterwards adds:—"the name Iguanodon, derived from the form of the teeth, (and which I have adopted at the suggestion of the Rev. W. Conybeare,) will not, it is presumed, be deemed objectionable." (Ib., p. 184.)

The fortunate discovery by Mr. Bensted was one of those which Baron Cuvier foresaw, and which has served to verify his sagacious conjecture, that some of the great bones collected by Dr. Mantell from the Wealden of Sussex, belonged to the same animal, unique in its genus, as the teeth; and also to confirm the accuracy of their discoverer's determination of the clavicle, femur, and tibia, figured and described by him in the 'Geology of the South-east of England,' 8vo, 1833, pp. 307—10, Pls. II and III.

In the work entitled 'Wonders of Geology,' in which the author gives a miniature view of the parts of the skeleton of the Iguanodon, recomposed by Mr. Bensted and himself, he points out several "vertebræ of the back and tail," "ribs," "the two clavicles," "one of the bones (*radius*) of the fore-arm (subsequently recognised by Mr. G. B. Holmes, of Horsham, and by Dr. Mantell, as the humerus)," "two *metacarpal* bones," "the two ossa ilia," "the right and left thigh-bone, or *femur*," "a leg-bone, or *tibia*," "bones of the toes (*metatarsal* and *phalangeal*) of the hind feet." The parts marked "6" as metacarpals, are those named "*radius*" and "*ulna*" in '*Dinosauria*,' Pl. 2.

The femora measure each thirty-three inches in length, and one of them originally stood in a vertical position, as regards the strata, which are nearly horizontal; and it projected from the solid limestone bed, which embraced its lower extremity, and passed nearly through the superincumbent bed of sandstone. The author of the 'Notice of the Discovery of the Iguanodon in the Maidstone Quarry,'* infers from this circumstance a proof, "that these two beds, now so different in consistency, were, in the one case, '*loose sand*,' and in the other, '*tenacious mud*,' at the period when this shattered and decomposing body of the Iguanodon sank to the bottom of the sea, and became covered up by an abundant deposition." Dr. Buckland remarks, with reference to the discovery of this skeleton, in strata of the cretaceous period:—"That both the sand and the limestone are *marine* formations there can be no doubt; for though wood and vegetable substances are not uncommon in these beds, yet the limestone abounds in ammonites, shark's teeth, and other sea productions, while a small sea-shell was also found fixed upon one of the bones of the Iguanodon." Both strata of the Kentish Rag are now satisfactorily proved to belong to the neocomian or lower division of the Greensand formation, which intervenes between the Wealden and the upper Greensand, or in some parts of England between the Wealden and the Chalk. Dr. Buckland has

* 'Philos. Magazine,' loc. cit.

remarked, in reference to this discovery of the Iguanodon, that it "shows that the duration of this animal did not cease with the completion of the Wealden series. The individual from which this skeleton was derived had probably been drifted to sea, as those which afforded the bones found in the fresh-water deposits subjacent to this marine formation had been drifted into an estuary."*

One of the chief advantages of Mr. Bensted's remarkable discovery, is the demonstration which it affords of the vertebral characters of the Iguanodon,—an important evidence of organisation, the difficulty of obtaining which will be appreciated by reference to my 'Report on British Fossil Reptiles,'† in which descriptions of the various vertebræ that had been found in the Wealden up to the year 1841 are given.

In the point of view in which I have had this remarkable and unique collection of the remains of one and the same animal figured, there are four vertebræ with their bodies in natural juxtaposition at the upper corner opposite the right hand, and the same number a little dislocated at the lower corner of the specimen. The latter show the characteristic neural arch in the best state of preservation, and the second of these vertebræ is represented of the natural size in Pl. 3.

In neither of these series, nor, indeed, in any part of the specimen, is there a vertebra with a parapophysis, or articular tubercle or impression for a rib, upon the centrum,—a character indicative of one from the neck or anterior part of the thorax. The whole of the exposed outer surface of the centrum, save the two extremities, is smooth or "non-articular," as in the middle and hinder parts of the trunk in the Crocodilia. Both the terminal or articular surfaces of the centrum are slightly concave, and with a nearly circular contour, with the vertical diameter slightly predominating (Pl. 4); the sides of the centrum rapidly contract as they recede from the articular ends towards the middle of the vertebra, and are chiefly remarkable for the almost plane surface which they form as they converge towards the lower surface of the centrum, the middle part of which is thus somewhat wedge-shaped, but with the lower border obtuse, and slightly concave lengthwise, as shown in Pl. 3.

The converging sides are, however, slightly convex vertically, more concave transversely; the free surface is traversed by fine longitudinal linear impressions. The neurapophyses have coalesced with each other and with the neural spine (*ns*) above, forming a remarkably broad and lofty neural arch, the base of which (*n n*) is still articulated by suture in this young Iguanodon to the centrum. In a few of the vertebræ this persistent suture has permitted a dislocation of the arch. The base of the neurapophysis is coextensive with the centrum lengthwise, and is developed inwards, transversely, so as almost to meet its fellow and circumscribe the neural canal. As the neurapophysis ascends it diminishes at first, in both diameters, and then again increases

* Bridgwater Treatise, vol. i, p. 241.

† Transactions of the 'British Association,' 1841, pp. 84—133.

above the neural canal, expanding where it coalesces with its fellow, and developing outwards a broad and strong platform, *n′ n′*, which surpasses the base of the neurapophysis both in length and breadth. The platform is chiefly supported by a buttress-like ridge, which rises nearly vertically from the hinder and outer angle, *n′*, of the base of the neurapophysis, and gradually expands as it ascends, inclining a little forwards to blend with the under part of the overhanging platform. The rudiment of a transverse process, *p*, answering to the lower one or "*parapophysis*," in the vertebra of the Crocodile, ('*Crocodilia*,' Pl. 1 D, fig. 3, *p*,) extends from the side of the neurapophysis anterior to the buttress; its base presenting the form of an oval with the long axis vertical, and the small end upwards, from which a smooth, convex prominence extends upwards and forwards, and subsides on the base of the anterior zygapophysis, which is developed from, or terminates, the fore-part of the neural platform. This transverse process is very short, and afforded an articular surface for the head of the rib. The second transverse process, answering to the upper one or "diapophysis" in the vertebra of the Crocodile (Ib., fig., 3 *d*,) which has been broken away in this specimen, is better preserved in the vertebra nearest the upper border of the slab in the 'Dinosauria,' Pl. 1, and in a few other detached vertebræ. The anterior zygapophyses scarcely project as distinct processes from the neural platform, but seem to form the natural anterior boundary of that part; their thickness gradually diminishes to an edge anteriorly, and their flat oval articular surfaces look obliquely upwards and inwards. The posterior articular surfaces are developed from the under and back part of the neural platform, and look downwards and outwards, over-hanging the hinder surface of the centrum. This part of the neural arch has been somewhat crushed and depressed in the vertebra which best shows its characters amongst those in Mr. Bensted's specimen; but one may see that the plane from which the neural spine rises has sloped from behind downwards and forwards. The base of the neural spine is coextensive with the neural platform; from the middle line of which it rises, but it contracts as it ascends, and inclines backwards; its height is shown to equal that of the rest of the vertebra in one that lies between the humerus and femur; although it has there suffered fracture; in the other specimens the broken summits of the spines have not been preserved.

In the characters above defined we may plainly recognise a vertebra differing from any of those that have been previously described; from those of the Crocodiles and Gavials ('*Crocodilia*,' Pls. 1 D, 3, 3 A, 3 B,) in the flattened articular ends of the centrum; and by the same character from those of the Ophidian, ('*Ophidia*,' Pls. 2 and 3,) and Lacertian ('*Lacertia*,' Pls. 1, 2, 8 and 9,) reptiles, which we have hitherto met with in the Tertiary and Cretaceous deposits; it is equally distinct from the biconical and short vertebræ of the Ichthyosaurus, ('*Enaliosauria*,' Pl. 7.) Were the centrum of the Iguanodon's vertebra ('*Dinosauria*,' Pl. 3,) to be found detached from the neural arch, it might not be so easy to distinguish it from that of a dorsal vertebra of a *Plesiosaurus*, which is similarly

characterised by nearly flattened articular extremities; but although the vertebræ are very variable in their proportions as to length and breadth in the different species of *Plesiosaurus*, I have hitherto found none that combine the same antero-posterior diameter with the nearly flattened, inferiorly converging, sides of the dorsal centrum, as in the Iguanodon. When, however, the entire vertebra can be compared, or the chief characters of the neural arch of the Iguanodon, with the tallying parts in the *Plesiosaurus*, important differences present themselves. In the cervical region of the *Plesiosaurus*, the neural arch is comparatively low and simple, and sends off no other processes save the zygapophyses and spine: in the dorsal region a diapophysis is superadded; but this alone offers an articular surface for the rib, and there is not any rudiment of parapophysis or of a parapophysial articulation for the head of the rib, such as is shown at *p*, Pl. 3. In the presence of this lower transverse process with the surface for the head of the rib, in the Iguanodon, developed either from the side of the centrum (as in the anterior dorsal vertebræ), or from the side of the neural arch (as in the middle dorsal vertebræ), we have a character* distinguishing it from *Ophidia*, *Lacertilia*, and *Enaliosauria*, whilst in the strong bony platform, in which the summit of the neural arch expands, with its supporting buttresses, we have an additional character distinguishing it from all known Crocodilia; and indicative of a distinct order of reptiles.

The importance of the characters deducible from Mr. Bensted's invaluable discovery, will be plainly manifested when the detached vertebræ and other fragmentary remains of large Saurians come to be described in the 'Monograph on the Wealden Reptiles,' and I proceed next to notice those of some caudal vertebræ which are well-preserved in the Maidstone specimen; they are marked '*c. vertebræ*' in Pl. 2, and one of the most perfect is figured of the natural size in Pl. 5. The centrum is more compressed than in the trunk, its articular ends are less expanded, but the flattened character of the inferiorly converging sides of the centrum being retained, this part presents in a more marked degree the wedge-shaped figure; the converging

* First made known in my 'Report on British Fossil Reptiles,' Trans. Brit. Association, 1841, p. 127. "In the interspace of the two buttresses of the anterior dorsal vertebræ there is a large oval articular surface, convex at the anterior, and concave at the posterior part, which has afforded a lodgement to the head of the rib." The nature of the part affording this surface is described in the next page as "the transverse process" which "extends from the side of the neurapophysis." At the commencement of my 'Report' I defined the "transverse processes" as being "of two kinds, superior and inferior," (p. 48,) but I did not, in that 'Report,' specify them by the names "diapophysis" and "parapophysis:" the process in question for the head of the rib is the "parapophysis." The author of the Appendix to Dr. Mantell's Paper, in the 'Philosophical Transactions,' 1849, assuming the "upper transverse process" to be the one indicated in my description of the fractured vertebra, No. 2160, imputes to me what he conceives to be an error (p. 291); but the error lies in his assumption. It is one amongst many instances of the necessity of abandoning the vague term 'transverse process,' and the advantage and propriety of the definite names "diapophysis" and "parapophysis," which I have been in the habit of using since the publication of my 'Report' in 1841.

sides, however, are separated below by a broader quadrate tract which is slightly concave transversely, and more so lengthwise, with each of its angles developed into an articular hypapophysis, *y′ y′*, for the junction of a portion of the base of a hæmal arch. This part, which is shown in Pls. 1 and 2, near the middle of the upper border of the slab, consists, as usual, of a pair of "hæmapophyses," but they are confluent with one another, not only where they form the base of the long hæmal spine, but also at their opposite extremities; and the hinder hypapophysial surfaces, *y′ y,′* which are the largest, also run into one another across the middle line. The articular end of the centrum, fig. 1, presents something between a quadrate and an elliptical form, with the long axis vertical; it is a little depressed within the border. The neural arch is anchylosed to the centrum; a rudiment of a parapophysis appears at the side of its base (fig. 2); the diapophysis, *d*, rises above and behind this, and extends obliquely upwards, outwards, and backwards; its extremity is broken off. The zygapophyses, *z*, are reduced to short tuberosities, without articular surfaces in this region of the spine; and the neural platform and its buttresses are quite suppressed. The summit of the neural spine is broken away.

Amongst the portions of ribs that are preserved, some show clearly not only the head but the neck and an articular tubercle; superadditions, which at once remove the *Iguanodon* from the *Iguana* and all its Lacertian congeners, and show the nearer affinity of the great Dinosaur to the Crocodiles. In one of the specimens near the upper part of the slab, as figured in Pl. 1, there is an indication of the upper part of the neck of the rib rising and bifurcating near the tubercle, whence it is continued as two ridges which form an anterior and posterior margin, as it were produced and overhanging the body of the rib. This character may not be without its value in detecting and determining fragments of ribs, which are common among the fossils of the strata containing the remains of great reptiles.

Both the bones, answering to those from the Wealden of Tilgate, which Cuvier thought "might be a clavicle,"* are preserved in the Maidstone specimen, having the same long, slender, triedral shaft slightly expanded, flattened and bent at one extremity; more expanded, flattened, and bent at an open angle at the opposite end; with a short pointed process sent off at the angle, and a broad subquadrate flattened plate projecting from the same border of the bent and expanded end, which has a truncate termination. In the *Cyclodus*† lizard I find the clavicle is bent at an open angle, but nearer its middle part; and the difference between this and the nearly

* Quoted by Dr. Mantell, in 'Geology of the South-East of England,' 1833, p. 308.

† This is the Lizard referred to in the following passage of Dr. Mantell's Paper, in the 'Philosophical Transactions,' 1841, p. 138. "In a very small Lizard in the Hunterian Museum, Mr. OWEN pointed out to me a bone attached to the coracoid and omoplate, that bore some analogy to the one in question:" it bears sufficient analogy to support the conclusion in the text, but lends no countenance whatever to the idea of the fossil in question being a peculiar superaddition to the Saurian skeleton, requiring a new name. The "os Cuvieri" is, in fact, abandoned in the Paper, in the 'Phil. Trans.,' 1849.

straight clavicle of the *Iguana*, *Amblyrhynchus*, and some other lizards, justifies the expectation of some unexampled modifications of that variable bone in a great extinct reptile of a different order.

For a knowledge of the bone, called "scapula" and "humerus," in Pl. 2, I am indebted to Mr. George B. Holmes, of Horsham, who, in March, 1847, transmitted to me a beautiful drawing of both bones, together with the coracoid in natural juxtaposition with the humerus, discovered "in one block of stone, with other bones of the same individual" in Tower Hill Pit, near Horsham. That gentleman, whose collection of the Wealden Fossils in his neighbourhood is one of the most instructive extant, had correctly determined their nature, and named them in the drawing which he sent to me "Humerus, Scapula, and Coracoid bone of the Iguanodon."

Dr. Mantell published similar determinations of homologous bones, in the 'Philosophical Transactions' for 1849. This part of the skeleton of Iguanodon may, therefore, be regarded as definitely restored.

The scapula in the Maidstone specimen, Pl. 1, lies broken across the femur: it is a long, narrow, flattened bone, gradually expanding to its free end, more suddenly towards its articular end; but this is too much mutilated to give its true character in the specimen in question: it will be described from Mr. Holmes's beautiful specimen in Section III, 'On the Fossil Reptilia of the Wealden Formation.'

The humerus (see Pl. 2) is shorter than the scapula, and much shorter than the femur, its relative proportions to which are the same in the Iguanodon, as in the Teleosaurus, (see '*Crocodilia*,' Pl. 1,) and, with the vertically developed tail of the Iguanodon, indicate the aquatic habits of that gigantic reptile. The head of the humerus is hemispheroid, and projects between two sub-equal tuberosities; a deltoid ridge is continued nearly half way down the bone from the outer tuberosity, and, where it subsides, the shaft is bent a little inwards, contracts, and then again expands to the distal condyles, which are rounded and prominent, with a moderately deep depression between them at the back, which is the part of the bone exposed in the Maidstone specimen.

The radius and ulna lie with their proximal ends next the right hand upper corner of the slab of the Maidstone specimen; the latter being distinguished by its prominent olecranon, which is rounded as in the great Monitor (*Varanus niloticus*). I shall reserve the description of the metacarpal and metatarsal bones for the succeeding Section; and shall only observe, here, that the claw-bones marked "ungual phalanx," in Pl. 2, though varying in their proportions in the two specimens preserved, are broader, more depressed, and less incurved than those of other known Saurians.

The ilium which lies detached near the lower border of the slab in the Maidstone specimen, is the left one, with its sacral articular surface or inner surface uppermost, the extent of which plainly indicates the great length of the sacrum in the Iguanodon, as compared with existing Lizards, since it equals the antero-posterior diameter of five

of the dorsal vertebræ; the part of the bone which is prolonged backwards beyond the articular part is slender, and terminates in an obtuse point. The right ilium, which is overlapped by one of the clavicles, shows that the anterior end bends outwards in the form of a thick tuberosity, and the expanded portion contributes by its lower border the usual share in the formation of the acetabulum.

The two *femora* (Pl. 2, *femur,*) well exemplify the characteristic peculiarities of this bone in the Iguanodon: its inwardly projecting hemispheric head, its much flattened trochanter, the compressed ridge-like process from the middle of the inner surface of the shaft, and the deep and narrow fissure between the distal condyles. This part of the femur had been figured and referred by Dr. Mantell to the Iguanodon, in his 'Geology of the South-East of England,' Nov. 1833, p. 310, pl. IV, figs. 3 and 4; and the subsequent discovery of the Maidstone specimen confirmed the accuracy of that determination.

The bone which is figured in Pl. II, fig. 8 of the same work, as the tibia of the Iguanodon, is also shown to be correctly so called by the Maidstone specimen, '*Dinosauria,*' Pls. 1 and 2.

The following are the dimensions of the principal and best-preserved bones in that specimen:—

Dorsal Vertebræ.

	Inches.	Lines.
Antero-posterior diameter of centrum	3	10
Vertical diameter of articular end	4	0
Transverse diameter of ditto	3	1
From the base of the neurapophysis to the fore-part of that of the spinous process	3	0
From ditto ditto back part of ditto	4	0
Antero-posterior extent of neural platform	4	6

Caudal Vertebræ.

	Inches.	Lines.
Antero-posterior diameter of centrum	2	5
Vertical diameter of articular end	2	5
Transverse diameter of ditto	1	11
From the base of the neurapophysis to the fore-part of that of the spinous process	1	3
From ditto ditto back part of ditto	1	6

Clavicle.

	Inches.	Lines.
Length of the bone	37	0
Breadth across the process at the broader end	8	0
Breadth across the narrower end	4	0

Scapula.

	Inches.	Lines.
Length of the bone	29	0
Breadth across the middle of the shaft	3	0

Humerus.

Length	19	0
Breadth of proximal end	6	0
Breadth of distal end	4	0

Ulna.

Length	18	0
Breadth of proximal end	3	0

Ilium.

Length	30	0
Breadth across the enlarged end	10	0
Extent of sacro-iliac articulation	19	0

Femur.

Length	33	0

Tibia.

Length	31	0

The detached teeth and bones of the Iguanodon successively discovered in the Wealden strata of Sussex, and afterwards found associated together to the extent of nearly half the skeleton of one and the same individual in the Green-sand quarries of Mr. Bensted, offer not the least marvellous or significant evidences of the inhabitants of the now temperate latitudes during the later secondary periods of the formation of the earth's crust.

With vertebræ flat or subconcave at their articular extremities, having, in the dorsal region, lofty and expanded neural arches, and doubly articulated ribs, and characterised in the sacral region by their unusual number and complication of structure; with a Lacertian pectoral arch, crocodilian proportions of the fore-limbs, and unusually large bones of the hind limbs, excavated by large medullary cavities and adapted for terrestrial progression, as well as for natation;—the *Iguanodon* was distinguished by

teeth, resembling in shape those of the Iguana, but in structure differing from the teeth of that and every other known reptile, and unequivocally indicating the former existence in the Dinosaurian Order of a gigantic representative of the small group of living lizards which subsist on vegetable substances.

The important difference which the fossil teeth presented in the form of their grinding surface was pointed out by Cuvier,* of whose description Dr. Mantell adopted a condensed view in his 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 72. The combination of this dental distinction with the vertebral and costal characters, which prove the *Iguanodon* not to have belonged to the same group of Saurians as that which includes the Iguana and other modern lizards, rendered it highly desirable to ascertain by the improved modes of investigating dental structure, the actual amount of correspondence between the *Iguanodon* and Iguana in this respect. This I have done in my general description of teeth of reptiles,† from which the following description is abridged:—

The teeth of the *Iguanodon*, though resembling most closely those of the Iguana, do not present an exact magnified image of them, but differ in the greater relative thickness of the crown, its more complicated external surface, and, still more essentially, in a modification of the internal structure, by which the *Iguanodon* equally deviates from every other known reptile.

As in the Iguana, the base of the tooth is elongated and contracted; the crown expanded, and smoothly convex on the inner side; when first formed it is acuminated, compressed, its sloping sides serrated, and its external surface traversed by a median longitudinal ridge, and coated by a layer of enamel, but beyond this point the description of the tooth of the *Iguanodon* indicates characters peculiar to that genus. In most of the teeth that have hitherto been found, three longitudinal ridges traverse the outer surface of the crown, one on each side of the median primitive ridge; these are separated from each other, and from the serrated margins of the crown by four wide and smooth longitudinal grooves. The relative width of these grooves varies in different teeth; sometimes a fourth small longitudinal ridge is developed on the outer side of the crown. The marginal serrations, which at first sight appear to be simple notches, as in the Iguana, present under a low magnifying power the form of transverse ridges, themselves notched, so as to resemble the mammillated margins of the unworn plates of the elephant's grinder: slight grooves lead from the interspaces of these notches upon the sides of the marginal ridges. These ridges or dentations do not extend beyond the expanded part of the crown: the longitudinal ridges are continued further down, especially the median ones, which do not subside till the fang of the tooth begins to assume its subcylindrical form. The tooth at first increases both in breadth and thickness; it then diminishes in breadth, but its thickness goes on

* Ossemens Fossiles, 1824, vol. v, part ii, p. 351.

† Odontography, part ii, p. 249; and Transactions of the British Association, 1838.

increasing; in the larger and fully formed teeth, the fang decreases in every diameter, and sometimes tapers almost to a point. The smooth unbroken surface of such fangs indicates that they did not adhere to the inner side of the maxillæ, as in the Iguana, but were placed in separate alveoli, as in the Crocodile and Megalosaur: such support would appear, indeed, to be indispensable to teeth so worn by mastication as those of the *Iguanodon*.

The apex of the tooth soon begins to be worn away; and it would appear, by many specimens that the teeth were retained until nearly the whole of the crown had yielded to the daily abrasion. In these teeth, however, the deep excavation of the remaining fang plainly bespeaks the progress of the successional tooth prepared to supply the place of the worn out grinder. At the earlier stages of abrasion a sharp edge is maintained at the external part of the tooth by means of the enamel which covers that surface of the crown; the prominent ridges upon that surface give a sinuous contour to the middle of the cutting edge, whilst its sides are jagged by the lateral serrations: the adaptation of this admirable dental instrument to the cropping and comminution of such tough vegetable food as the *Clathrariæ* and similar plants, which are found buried with the *Iguanodon*, is pointed out by Dr. Buckland, with his usual felicity of illustration, in his 'Bridgewater Treatise,' vol. i, p. 246.

When the crown is worn away beyond the enamel, it presents a broad and nearly horizontal grinding surface, and now another dental substance is brought into use to give an inequality to that surface; this is the ossified remnant of the pulp, which, being firmer than the surrounding dentine, forms a slight transverse ridge in the middle of the grinding surface: the tooth in this stage has exchanged the functions of an incisor for that of a molar, and is prepared to give the final compression, or comminution, to the coarsely divided vegetable matters.

The marginal edge of the incisive condition of the tooth, and the median ridge of the molar stage, are more effectually established by the introduction of a modification into the texture of the dentine, by which it is rendered softer than in the existing Iguanæ and other reptiles, and more easily worn away: this is effected by an arrest of the calcifying process along certain cylindrical tracts of the pulp, which is thus continued, in the form of medullary canals, analogous to those in the soft dentine of the Megatherium's grinder, from the central cavity, at pretty regular intervals, parallel with the calcigerous tubes, nearly to the surface of the tooth. The medullary canals radiate from the internal and lateral sides of the pulp cavity, and are confined to the dentine forming the corresponding walls of the tooth: their diameter is $\frac{1}{1250}$th of an inch: they are separated by pretty regular intervals equal to from six to eight of their own diameters; they sometimes divide once in their course. Each medullary canal is surrounded by a clear space; its cavity was occupied in the section described by a substance of a deeper yellow colour than the rest of the dentine.

The calcigerous tubes present a diameter of $\frac{1}{25,000}$th of an inch, with interspaces

equal to about four of their diameters. At the first part of their course, near the pulp cavity, they are bent in strong undulations, but afterwards proceed in slight and regular primary curves, or in nearly straight lines to the periphery of the tooth. When viewed in a longitudinal section of the tooth, the concavity of the primary curvature is turned towards the base of the tooth: the lowest tubes are inclined towards the root, the rest have a general direction at right angles to the axis of the tooth; the few calcigerous tubes, which proceed vertically to the apex, are soon worn away, and can be seen only in a section of the apical part of the crown of an incompletely developed tooth. The secondary undulations of each tooth are regular and very minute. The branches, both primary and secondary, of the calcigerous tubes are sent off from the concave side of the main inflections; the minute secondary branches are remarkable at certain parts of the tooth for their flexuous ramifications, anastomoses, and dilatations into minute calcigerous cells, which take place along nearly parallel lines for a limited extent of the course of the main tubes. The appearance of interruption in the course of the calcigerous tubes, occasioned by this modification of their secondary branches, is represented by the irregularly-dotted tracts in the figure. This modification must contribute, with the medullary canals, though in a minor degree, in producing that inequality of texture and of density in the dentine, which renders the broad and thick tooth of the *Iguanodon* more efficient as a triturating instrument.

The enamel which invests the harder dentine, forming the outer side of the tooth, presents the same peculiar dirty brown colour, when viewed by transmitted light, as in most other teeth: very minute and scarcely perceptible undulating fibres, running vertically to the surface of the tooth, form the only structure I have been able to detect in it.

The remains of the pulp in the contracted cavity of the completely-formed tooth, are converted into a dense but true osseous substance, characterised by minute elliptical radiated cells, whose long axis is parallel with the plane of the concentric lamellæ, which surround the few and contracted medullary canals in this substance.

The microscopical examination of the structure of the Iguanodon's teeth thus contributes additional evidence of the perfection of their adaptation to the offices to which their more obvious characters had indicated them to have been destined.

To preserve a trenchant edge, a partial coating of enamel is applied; and, that the thick body of the tooth might be worn away in a more regularly oblique plane, the dentine is rendered softer as it recedes from the enameled edge by the simple contrivance of arresting the calcifying process along certain tracts of the inner wall of the tooth. When attrition has at length exhausted the enamel, and the tooth is limited to its function as a grinder, a third substance has been prepared in the ossified remnant of the pulp to add to the efficiency of the dental instrument in its final capacity. And if the following reflections were natural and just after a review of the external characters

of the dental organs of the *Iguanodon*, their truth and beauty become still more manifest as our knowledge of their subject becomes more particular and exact.

"In this curious piece of animal mechanism we find a varied adjustment of all parts and proportions of the tooth, to the exercise of peculiar functions, attended by compensations adapted to shifting conditions of the instrument, during different stages of its consumption. And we must estimate the works of nature by a different standard from that which we apply to the productions of human art, if we can view such examples of mechanical contrivance, united with so much economy of expenditure, and with such anticipated adaptations to varying conditions in their application, without feeling a profound conviction that all this adjustment has resulted from design and high intelligence."—('Buckland's Bridgewater Treatise,' vol. i, p. 249.)

In pursuing the search after the remains of Reptiles below the actual surface of the soil, through the Formations of the Tertiary deposits in this island, it was found, as has been shown in the First Section of the present Work, that the number and variety of those remains rapidly increased when we had arrived at the oldest or "eocene" division of the deposits; the general character of the organic remains in which demonstrate a warmer or more equable climate to have prevailed here during their formation. Under conditions so favorable to the existence of the cold-blooded class of air-breathing vertebrate animals, not only were the *Reptilia* larger and more numerous, but they were distinct from any of the few small species now existing in the British Islands; and most of them belonged to orders which, as, *e.g.*, the *Chelonia*, are either represented only by rare examples of the Marine Order, casually floated near or cast on our shores, or which, as, *e.g.*, the *Crocodilia*, are no longer represented by any indigenous species in Europe.

All the species of Eocene Reptilia, nevertheless, belonged to orders and families of the class which still exist in the warmer latitudes of the globe; and if some of the fossils may seem to have been distinct from corresponding parts of actual Genera, it was not from any of those great natural groups to which Linnæus restricted the term genus, but from the modern and less important sub-divisions of such, like those into which the Linnean *Colubri* have been dispersed, and to which sub-genera the *Palæophis* and *Paleryx* were correlative.

In short, to the bottom of the Tertiary Deposits, or, in other words, from the very commencement of that epoch in Geological time, we found only forms of the Reptilia so little modified from those now existing as irresistably to impress us with the conviction that they played the same parts, under very similar influences and circumstances, which are performed by the Gavials, Crocodiles, Alligators, Turtles, Terrapenes, Mud Tortoises, Lizards, and Serpents of the present day.

But this aspect of Reptilian life rapidly fades away as we pursue our course through the dark vistas of the past. The slow and massive *Chelonia*, indeed, characterised by their tenacity of life and the sluggishness of its manifestations, continue to retain the characteristic forms of the principal modifications of their Order, but little altered. The *Chelone Camperi* and *Chelone Benstedi* do not differ more from the modern Turtle of gastronomic repute than do the numerous forms that paddled about the estuary of Sheppey in the oldest Tertiary times. The modifications of the Emydian from the Green-sand of Maidstone are not of greater value than may be expressed by a sub-generic name, in accordance with the adopted practice of modern Herpetologists.

When, however, we look for species of the modern Crocodiles, Alligators, and Gavials, in the strata that immediately follow the Tertiary beds in descending order, we nowhere find an unequivocal trace of them. Not a fragment of the numerous vertebræ that enter into the composition of the much-prolonged spinal column of the procœlian *Crocodilia* has yet been discovered in any of the widely-dispersed Formations of the Chalk or Green-sand periods, although some of the latter were so situated as to have received occasional evidences, as in the case of the *Protemys*, of the Reptilian inhabitants of the Fresh-waters or Estuaries.

The only Saurian vertebræ with a cup at the front and a ball at the back part of the body, from the Cretaceous deposits, belong to the Lacertian not to the Crocodilian Order; and the most remarkable of these vertebræ show a modification of the Lacertian type very distinct from any existing form, being adapted more expressly for aquatic, and without doubt marine, life, and, attaining, under favour of that medium of existence, a bulk surpassing the largest of the modern *Crocodilia*. The *Mosasaurus* combined a carnivorous form of teeth with an anchylosed mode of their attachment, as in many Fishes and in the Acrodont Chameleons and Agamian Lizards, and with a disposition of the teeth on the maxillary and pterygoid bones, as in many of the true Lizards, and in the Anolian, Scincoid, and Iguanian families. The vertebral column was modified for the act of swimming, by being unfettered by zygapophysial joints along more than the hinder half of its extent, as it is in the *Cetacea;* and by the anchylosis of long hæmal arches to the vertically-extended caudal vertebræ, as we find in many Fishes: and the trunk, composed of one hundred and thirty-three vertebræ, which supported a skull of four feet in length, cannot be reasonably calculated at less than from twenty to thirty feet in length. The extremities, though doubtless webbed and adapted for swimming, like those of the Gavial, yet appear, from the evidence adduced in the text, to have been formed, as in the Crocodilian type, for occasional locomotion on land; yet the absence of any trace of a sacrum combines with the ascertained modifications of the vertebral column, in indicating a more strictly marine life in the *Mosasaurus* than in any modern Lizard. The ascertained modifications in the structure of the skeleton of this large extinct Lacertian demonstrate, in fact, that

it had no such near affinities to any of the existing genera, as to have constituted a link intermediate between any two of them; but that it manifested a type of the Lacertian organisation, representing a division of the Order *Lacertilia*, adapted for marine life, equivalent in character to the remainder of the Order as represented by the existing terrestrial species; and I have, therefore, indicated those two divisions or tribes of the Order *Lacertilia* by the terms *Natantia* and *Repentia*.

The Lacertian Order expands as our survey of its existence in past time extends backwards; and the same direction of development becomes more striking as we carry our retrospect over the whole Reptilian Class. A new Order, with an organisation more expressly adapted for marine life than in the *Mosasaurus*, comes into view when we descend to the Chalk-beds, where it is represented by the remains of the *Ichthyosauri* and *Plesiosauri* described in the Fourth Chapter of the present Section. Evidence of another Order of Reptiles, distinct from any now left to us, was given by the discovery of the Iguanodon in the Green-sand of Maidstone. But the most striking modification of the Reptilian structures is afforded by those remarkable specimens of Pterodactyles, discovered in the Middle-chalk itself, and described in the Fifth Chapter of the present Section.

Succeeding Sections devoted to the Fossil Reptiles of still older Strata will bring to light additional and varied forms of *Enaliosauria*, *Pterosauria*, and *Dinosauria*, and also of tribes of *Crocodilia* no longer existing. All these modifications of the once richly developed Class of Reptiles perished, according to our present evidence, during the period of the deposition of the Chalk Formations, after which we know that the seas of our Planet were peopled with carnivorous fish-like animals of the warm-blooded Mammalian Class, and its dry land with large herbivorous and carnivorous quadrupeds of the same highly-organised type.

In considering the marvellous fact of the disappearance or extinction of the Orders *Enaliosauria* and *Pterosauria*, we must bear in mind that the last Ichthyosaur of which we have been enabled to get cognizance preserves as strictly the type of its peculiar genus as any of its predecessors, and that in respect to the extent of cement outside its teeth, which is such as to lead to their being wedged squarely into their common alveolar groove, the *Ichthyosaurus campylodon*, instead of showing any approach or affinity to later forms of larger *Reptilia*, manifested a distinctive characteristic of its peculiar genus in an exaggerated degree. So likewise with regard to the Flying Reptiles, these seem at no period to have been represented by species so gigantic and formidable as during the most recent of the Secondary Formations; and the Order *Pterosauria*, instead of showing signs of progressive decay or transmutation, seems to have attained its highest and most typical development at the eve of its final extinction.

SECTION III.

THE

FOSSIL REPTILIA OF THE WEALDEN FORMATIONS.

Chapter I.—Order *DINOSAURIA.**

(Cervical and anterior dorsal vertebræ with parapophyses and diapophyses; dorsal vertebræ with a neural platform; sacral vertebræ exceeding two in number; body supported on four well-developed unguiculate limbs.)

Genus—Iguanodon.

Dentes incrassati, marginibus lammellosis.

In the preceding Section is recorded the history of the discovery, in the Green Sand formation, of that important collection of the bones of one and the same individual Reptile, from which we have been able to deduce, without any doubtful element of conjectural approximation or analogy, the characters of the dorsal and caudal vertebræ, of the teeth, of the scapular arch, iliac bones, and most of the bones of the extremities of the gigantic extinct species, for which Conybeare suggested the generic name of Iguanodon, and which Cuvier, with other systematic Palæontologists have denominated, after its original discoverer, *Iguanodon Mantelli.*

The satisfactory evidence which so rare a collection of parts of the same skeleton affords, induced me to commence my illustrations of this remarkable herbivorous Dinosaurian with Mr. Bensted's famous specimen: and I now proceed to describe the characters of the rest of the skeleton, so far as undoubted parts of it have been obtained from the Wealden Strata, in which the first evidences of the Iguanodon were discovered by Dr. Mantell, and from which the most abundant and varied remains of this remarkable herbivorous reptile have since been obtained.

* Report on British Fossil Reptiles, 1841, in 'Trans. Brit. Association,' 8vo, 1842, p. 102. Pictet, 'Traité Elémentaire de Palæontologie,' 8vo, tom. ii, 1845, p. 52. From the Greek δεινὸς, fearfully great; σαύρος, a lizard.

IGUANODON MANTELLI.

Description of part of the Skeleton of a Young Iguanodon. Pl. 6. Nat. size.

A considerable and very instructive part of the skeleton of a young Iguanodon, the entire body of which was probably under two yards in length, was discovered in the Wealden formations, about one hundred yards west of Cowleaze Chine, on the south-west coast of the Isle of Wight, in the year 1849.

The mass of Wealden stone in which this skeleton was imbedded, was broken into two parts in its extraction from the bed; and, as happened with the skeleton of the Dolichosaurus, described in a former Section,* the workmen disposed of one part to one collector, and of the other to another. Mr. Bowerbank was so fortunate as to become the possessor of that portion which contained the most important part of the skeleton, and which forms the upper division of the chief figure in Pl. 6, (*Dinosauria*) where it is represented of the natural size.

This portion includes seventeen vertebræ, extending from the neck to near the pelvis inclusive: the pelvis apparently forms a continuation of the vertebral series, but is obscured by the principal bones of the right hind foot, *mt*, *pl*, 1 and 2. Some portions of ribs, *pl*, *pl*, and of a coracoid, 52, in the proximal part of the left femur, 65, the distal halves of the right tibia, 66, and fibula, 67, and a fragment of the left tibia, 66, are also imbedded in the same block of stone. The other portion of the block fell into the possession of Dr. Mantell, and is now in the British Museum. It includes eleven consecutive caudal vertebræ, with some of their hæmapophyses, *h*, *h*; the right femur, 65, the proximal halves of the right tibia, 66, and fibula, 67, and parts of the left tibia, 66′, and fibula, 67′. The bones of the right hind leg are almost completed when the blocks containing their opposite ends are brought into juxtaposition, as in Pl. 6.

Of the seventeen vertebræ, in Mr. Bowerbank's specimen, the three anterior, 1, 2, 3, have been detached and carefully worked out: they appear to have immediately preceded the rest which remain imbedded in the block, and which are unequivocally consecutive; including the detached three, the seventeen vertebræ occupy an extent of thirteen inches.

The first three vertebræ, as imbedded and naturally cemented together, exhibit a slight upward curvature, and the five following vertebræ are bent in the same direction, but in a less degree: the rest present a moderate bend with the concavity downwards or towards the abdomen. The whole of this series, therefore, describes a gentle sigmoid curvature, like that which may be observed in the naturally articulated

* 'Fossil Reptilia of the Cretaceous Formations,' p. 176. Cuvier had to contend with similar difficulties; see 'Ossem. Foss.,' t. v, pt. ii, p. 148.

vertebral column of a young Alligator from the fourth cervical to the first lumbar vertebræ inclusive; which vertebræ are also seventeen in number in that reptile. Supposing the vertebræ of the young Iguanodon in question to be the homologous or nearly homologous vertebræ to those of the Alligator compared, the characters of the cervical vertebræ are given by the detached specimens, 1, 2, and 3, fig. 1, and figs. 2, 3 and 4, forming the anterior end of the series, and the degree of curvature shown by these vertebræ, which have been fixed together by the matrix, as they were naturally juxtaposed at the animal's death, and the slenderness of the portions of the ribs, *pl*, fig. 2, therewith preserved, add to the probability that they belonged to the neck.

In my 'Report on British Fossil Reptiles,' 1841, tom. cit., p. 126, I showed that the cervical vertebræ, which had been referred by Dr. Mantell to the Iguanodon, on the supposition that such vertebræ had ball and socket articular extremities, placed as in the neck-vertebræ of the Iguana, had, in fact, these articular surfaces situated in a reverse position to those in the Iguana and most existing Saurians; and that they agreed in that peculiarity with the vertebral characters which Cuvier had demostrated* in an extinct Saurian genus, subsequently called *Streptospondylus.* I had previously, however,† suggested the possibility that such streptospondylian vertebræ from the Wealden might be the cervical ones of a large Saurian having plain-surfaced or concave vertebræ in the dorsal and lumbar regions. The authors of the paper 'On the Osteology of the Iguanodon,' in the 'Philosophical Transactions' for 1849, adopting this idea,‡ have applied it to the Iguanodon itself, but on no better grounds than a conjectural guess, which considerations of difference in other characters and proportions forbad my hazarding, when maturely considering the nature of the anteriorly convex vertebræ from the Wealden, in my 'Report.' Accordingly, in regard to the cervical vertebræ of the Iguanodon, I restricted myself to the following remark: "The desirable knowledge, therefore, of the anatomy of that region of the spine in the Iguanodon, which in other Saurians is usually distinguished by its well-marked and varied characters, remains to be acquired." p. 126.

* 'Ossem. Foss.,' v, pt. ii, p. 153, pl. 8 and 9. † 'Report,' Op. cit., p. 96.

‡ P. 273. The reference to my observation is so made as to induce me to reproduce textually the passage in which the possible nature of Streptospondylian vertebræ was first indicated. "Since the vertebræ of the *Streptospondylus* lose their peculiar convexo-concave character by the gradual subsidence of the anterior ball, as they approach the tail, the cervical vertebræ of the *Cetiosaurus* may approach, more nearly than do the dorsal ones, to the convexo-concave structure of the Streptospondylian vertebræ. The fact that, hitherto, only cervical vertebræ of the great *Streptospondylus,* and only dorsal and caudal vertebræ of the *Cetiosaurus,* have been discovered in the Wealden formations, has induced me well to consider the grounds for assigning them to Saurians of distinct genera. But the general constancy of the vertebræ of the same Saurian in their antero-posterior diameter, forbids the supposition of a vertebra of six inches in length in the neck being associated with one of three inches in length in the back. Additional evidence of a very decisive character must at least be obtained before the great Cetiosaur can be admitted to have resembled the Pterodactyle in such disproportionate length of the cervical vertebræ." p. 96.

The following are the characters of the cervical vertebræ in Mr. Bowerbank's young Iguanodon:

The centrum partakes of the characteristic of that part in the dorsal region, in its lateral compression and the convergence of its sides to a very narrow inferior surface: but this wedge-shaped characteristic is exaggerated in the present vertebræ; the sides are naturally more compressed between the fore and hind articular ends; they are concave, not only lengthwise but vertically, and they meet below at a ridge from which a process—the hypapophysis—appears to have descended; for, though the ridge itself, *hy*, figs. 2 and 4, extends below the level of the articular ends of the centrum, it shows a fractured edge; and the hypapophysis is the characteristic of the cervical region in most saurian reptiles. As the neural canal retains its original capacity—the arch showing no marks of pressure,—the compression of the middle part of the sides of the centrum cannot be regarded as the effect of crushing; it is the same on both sides, and the expanded articular ends seem to exhibit their natural and symmetrical form,* as in fig. 4, Pl. 6. This form differs from that in the dorsal region,† by being narrower in proportion to its depth, and repeats in this proportion the character of the same part in the caudal region;‡ but the contour of the cervical centrum is different from that of the caudal one: the anterior surface resembles an ancient shield, the sides slightly diverging as they descend to the parapophyses, and then more rapidly converging to the inferior ridge; the contour of the hinder surface, fig. 4, is an oval, a little flattened above at the larger end. The deep pit at the side of the centrum characteristic of the cervical and anterior dorsal vertebræ of the Streptospondyl is not present in the corresponding vertebræ of the Iguanodon. In these vertebræ the anterior articular surface is nearly flat vertically, very slightly concave at the middle, and as feebly convex above and below. Transversely the surface is slightly convex, and most so where it is continued, just above the middle of the surface, upon the parapophyses. The hinder surface is gently and pretty uniformly concave.

Both surfaces are devoid of that smooth or polished character which is observable in the Reptiles that have those surfaces coated by articular cartilage, and have their vertebral centrums articulated by synovial capsules; concentric striæ are plainly manifest near the border of the articular surface, whence I conclude that the vertebral bodies of the Iguanodon *were coarticulated by means of an intervertebral ligamentous substance, as in the class Mammalia*. That such substance intervened between these

* The assertion in the paper above cited, 'Phil. Trans.,' 1849, p. 303, that the three vertebræ here described "have been crushed and compressed almost flat laterally" has reference to an idea that they were homologous with the streptospondylian vertebra described in my 'Report,' p. 92, the different form and proportions of which are explained by the authors of that paper on the assumption that that vertebra "has been compressed in an opposite direction," ib. p. 303.

† Section II, 'Cretaceous Reptiles,' *Dinosauria*, pl. 3 and 4. ‡ Ib., pl. 7.

most freely moveable cervical vertebræ, and, *à fortiori*, therefore, between the less moveable dorsal, lumbar, and caudal vertebræ, is further indicated by the interval separating the centrums in the three cervical vertebræ preserved with the natural co-adaptation of their zygapophyses, and with their natural upward curvature, in the specimen figured in Pl. 6. The elasticity of the concentric ligamentous substance has permitted the vertebral bodies, in this upward flexure, to be more divaricated at their lower than at their upper borders.

Nothing in the characters of these unequivocal vertebræ of the Iguanodon affords any countenance to the conjecture that the broad and sub-depressed convexo-concave, or streptospondylian vertebræ, which I had stated might be a cervical modification of the vertebral column of the Cetiosaur, are from the cervical region of the Iguanodon. The parapophysis of the true cervical vertebræ of this reptile, figs. 2 and 4, *p*, is developed, in a great proportion from the centrum, in a less proportion from the neurapophysis, close to the anterior articular end of the centrum, which surface is continued upon the parapophysis. This process is short, obtuse, and terminates by a surface for the attachment of the head of the rib.

The neurapophyses, which are confluent at their summit, remain free below, where they are joined by suture to the centrum, embracing the upper third of the articular end. They contribute, as above stated, a small proportion to the parapophysis; ascend a short way vertically with a smooth and concave outer surface, then develope large zygapophyses, and, from the outside of the anterior of these, *z*, send out a diapophysis, *d*, for articulation with the tubercle of the rib. The neural arch is notched before, and more deeply behind; there is a ridge above each zygapophysis, and these ridges converge to the base of the neural spine. The broad, flat articular surface of the anterior zygapophysis, *z*, looks inwards and a little upwards and backwards; that of the posterior zygapophysis, *z'*, exhibits, of course, the opposite aspects; the outer border of both zygapophyses is rounded. The zygapophyses are not connected, externally, by a ridge continued forwards and backwards from the diapophysis, as in the dorsal vertebræ, where such ridges form the neural platform, (Section II, 'Cretaceous Reptiles,') Pl. 3, *n*, *n'*. The neural canal is proportionally wider than in the dorsal vertebra of the older Iguanodon (Ib. Pl. 4), but this is no doubt due to both the comparative immaturity of the present specimen, and to the more advanced region of the spine, formed by the vertebræ under consideration.

The bases of the neurapophyses do not extend so far inwards as in the dorsal vertebræ, but leave a median tract of the floor of the neural canal which is formed by the centrum itself: this part of the centrum sinks into a hollow, and is perforated by the myelonal veins.

The antero-posterior extent of the base of the neural spine is two lines, that of the neurapophysis, between the extremes of the anterior and posterior zygapophyses, being thirteen lines: the spine is much compressed laterally: it has been broken off near its

origin in all the three detached vertebræ: there is a deep angular depression behind its base, between the two converging ridges from the posterior zygapophyses, probably for the implantation of an elastic ligament.

The proximal end of a slender pleurapophysis, *pl.* fig. 2, adheres by the matrix to the eft side of the second and third of the three vertebræ above described; the neck of the rib is moderately long and rounded, truncate, and not expanded at its articular end; the tubercle is produced, and beyond that the rib becomes compressed: unfortunately only a small part of the body of the rib is preserved.

Of the succeeding vertebræ, imbedded in the matrix, the flat or slightly concave character is resumed in the anterior surface of the centrum of the third, counting backwards.

The modification of the articular terminal surfaces, slight as it is in the cervical vertebræ above described, may be readily understood to relate to the corresponding increase in the extent and facility of motion of that part of the spine. But such modification gives no support to the idea that the vertebra, No. $\frac{116}{2116}$ in the British Museum, provisionally referred to the *Streptospondylus major* in my 'Report on British Fossil Reptiles,' p. 92, but with the intimation of its being possibly a cervical vertebra of the *Cetiosaurus brevis* (ib., p. 96),—and referred by Dr. Mantell to the *Iguanodon Mantelli* in the 'Geology of the South East of England,' 8vo, 1833, p. 300, really appertained to the cervical region of the Iguanodon.

We have not, as yet, any evidence of so marked and sudden a change in the forms and proportions of a cervical vertebra, between the dentata and the fourth or fifth, occurring in any reptile or mammal, as would be the case were the vertebræ, described in p. 92 of my 'Report on British Fossil Reptiles,' 1841, to belong to the Iguanodon; and the absence of such evidence prevents me now, as at the period when those vertebræ were first described, from hazarding or acceding to the hypothesis.

In the vertebræ succeeding those, 1, 2, 3, here regarded as cervical in the young Iguanodon, Pl. 6, the sides of the centrum continue to be compressed, with a surface flat vertically, and concave longitudinally, and meeting below at a ridge, as far as the twelfth, counting backwards, and including the three detached cervicals: at the fourteenth vertebra the lower part of the centrum is broader, and is convex transversely. The parapophysis has ascended upon the neurapophysis in the fifth vertebræ, counting backwards; and in the sixth the contour of the articular terminal surface is oval, with the small end downwards: it is shown to be elliptical in the sixteenth vertebra.

The neurapophysial sutures are retained throughout the series of the seventeen successive vertebræ. In the seventh, sufficient of the neural arch is preserved to show the interzygapophysial ridge, forming the base of the expanded bony platform, *n*; a part of the neural spine, *n* 5, of this vertebra is preserved, to an extent equaling the vertical diameter of the rest of the vertebræ: it is compressed, but of considerable

antero-posterior extent. The zygapophyses, *z*, *z'*, diminish in size, and their articular surfaces become more vertical as the vertebræ approach the pelvis. The left pleurapophyses, *pl*, *pl*, of the first five of the imbedded vertebræ, or those succeeding the three cervicals, seem to show a progressive and rapid augmentation of length, indicative of their formation of the fore part of the thorax, but the extremities of all their ribs appear to have been broken off: the inner surface, which is exposed, shows a longitudinal groove; traces of ribs continue to the seventeenth vertebra. There are impressions of spines of three vertebræ, beyond this, before we come upon the blended mass of the pelvis and hind foot. Before describing the pelvis, some notice is required of the peculiarities of those elements of the cervical and dorsal vertebræ which, from their development and retention of their primitive separation, are usually regarded as distinct bones, called "ribs."

Ribs of the Iguanodon. Pl. 7. One fourth the nat. size.

These appendages, or elements, of the vertebral column are present throughout a great proportion of its extent, but become anchylosed, and reduced to the character and function of transverse processes in the lumbar, sacral, and caudal regions. They are free and largely developed in the thoracic-abdominal region of the spine, at the fore-part of which they have the same two-fold connexion with the vertebræ as in the Crocodilians. In the cervical region the rib is articulated by a "head," supported on a long neck, to a short sessile inferior transverse process or "parapophysis," and by a large "tubercle" to a superior transverse process or "diapophysis;" a portion of a cervical rib is slightly disarticulated and turned forwards in one of the hinder cervical vertebræ of the young Iguanodon, figured in Pl. 6, fig. 2, so as to show most clearly the nature of this two-fold articulation; as the ribs increase in length, at the fore-part of the thorax, each is joined by a large head to a shallow cavity, situated at first on the side of the centrum and then on the side of the neurapophysis, as at Pl. 3, *p*, (*Dinosauria;*) and it was also articulated, as in the neck, by a tubercle, to the extremity of the diapophysis. In a certain number of the anterior thoracic vertebræ, the neck of the rib is co-extensive with the diapophysis, and is sometimes six or seven inches in length; afterwards the neck of the rib begins to shorten, and the head to decrease in size, and to have its place of articulation brought progressively nearer to the tubercle and to the end of the diapophysis, until it finally disappeared, and the posterior ribs became appended to the ends of the diapophyses.

In the Iguana, as in other Lizards, the ribs have but one mode of articulation, viz., to a simple tubercle developed from the side of the centrum.

One of the largest double-jointed ribs of the Iguanodon, in the Mantellian Collection (No. $\frac{519}{2519}$), is 46 inches in length, its proximal or vertebral end is represented

in Pl. 7, figs. 1 and 2. The neck is less distinct from the tubercle and body than in other ribs which seem to have been situated further back; it expands more gradually to the tubercular articulation with the diapophysis, and is at this part 5 inches in breadth; it bends with a deep oblique curve for about one fifth of its length, and then is continued in a nearly straight line to its extremity: this is slightly expanded and truncated, for the attachment doubtless of a bony sternal rib. The convex or outer margin of the rib is bent backwards so as to overhang the sub-compressed shaft of the bone along its upper or proximal third part.

The proximal extremity of one of the ribs from the middle of the trunk of the Horsham Iguanodon, presents an ovate head $2\frac{1}{2}$ inches in the long diameter; the neck is 7 inches long, straight, compressed, and topped by a well-marked tubercle, where it joins the body of the rib. This part is also compressed; and its external margin, besides being bent backwards, is also developed in the contrary direction, so as to assume the form of a slightly convex plate of bone 2 inches broad, attached at right angles to the shaft of the rib, which it overhangs on both sides. This structure is characteristic also of some of the ribs in the other Dinosaurs, and is interesting as indicating the commencement of that peculiar development of the corresponding part of the ribs in the Chelonian reptiles, by which, and their connexion with continuous dermal ossifications, the lid of their bony box is almost wholly formed.

In fig. 3, Pl. 7, is given a view of the upper surface of the head, neck, and tubercle, and expanded beginning of the shaft of a rib of an enormous Iguanodon, the part so represented measuring 10 inches in a straight line. A ridge is developed from the upper surface which, at the tubercle, expands into the overhanging plate of bone. In a more posterior rib, figs. 4 and 5, the tubercle is more distinctly developed, and continues so to be as the neck progressively shortens, as in figs. 6—10, Pl. 7. Fig. 8 gives a view of an almost entire pleurapophysis, or "vertebral" rib, from about the middle of the thoracic abdominal cavity, the length of which, in a straight line, from the tubercle to the fractured end of the body, is 32 inches. The common form of the body of the rib is that exemplified in the transverse section of the rib, given at fig. 1. The number of thoracic abdominal vertebræ, supporting such free and more or less elongated ribs, was probably about fifteen.

Sacrum of the Iguanodon. Pls. 8, 9, 10, 11. (Half nat. size.)

The facts ascertained relative to the structure of that part of the vertebral column, answering to the "true vertebræ" in Human Anatomy, of the Iguanodon, had tended, at the period of preparing my 'Report on British Fossil Reptiles,' in 1840, to rectify the ideas on the Lacertian affinities of that reptile, suggested by its name, and had proved the Iguanodon to belong to a more highly organized section of the then-defined Saurian

order than the Iguana and the rest of the Lizard-tribe. The two costal articulations viz., for the head and tubercle of the rib on the anterior dorsal vertebræ,* and the corresponding modifications of some of the ribs themselves,† indicated the great extinct herbivorous reptile of the Wealden to have enjoyed a double circulation, aided by a four-chambered heart as perfect in structure as that of the modern *Crocodilia*.‡ The peculiar expansion and complexity of the neural arch, so superior to the structure of that part in the Crocodile, and so distinct from the Ophidian modification of the same part in the Iguana,§ pointed to the former existence of a primary group of the class *Reptilia*, superior to and distinct from both the crocodiles and lizards of the present period. But the confirmation of the ideas and the resolution of the questions thus suggested depended on, or at least rendered very desirable, the detection of corresponding modifications of other parts of the vertebral column, and especially of that part which more immediately transferred the weight of the hinder parts of the trunk and the tail upon the—for a Saurian reptile—enormously developed hind limbs.

No sacrum of any recent or fossil cold-blooded animal had at that time been recognised as including more vertebræ than the typical number—two—in the reptilian class; and no single vertebra, or set of vertebræ, had then been referred to the sacrum of the Iguanodon. The Mantellian Collection in the British Museum, according to its catalogue, in the hand-writing of its founder, contained no sacral vertebræ. I suspected, indeed, at an early period of my investigations of our Fossil Reptilia, some detached centrums, or vertebral bodies, of a young Iguanodontoid Saurian, in that Collection, No. $\frac{127}{2127}$, *e*, *g*, to belong, from certain characters hereafter to be noticed, to the sacral region of the spine; but the proof, from better preserved specimens, was still wanting.

Every collection, public and private, to which I could command access, was ransacked for a specimen that might agree with the suspected characters of the great desideratum towards completing the vertebral anatomy of the Iguanodon. Some years passed away, leaving fruitless this research; until, in 1840, in the course of a systematic examination of the private collections in this metropolis, and whilst engaged in the comparison of the reptilian fossils in the well-stored museum of J. Devonshire Saull, Esq., F.G.S., in Aldersgate Street, City, my attention was arrested by a bulky and weighty mass of anchylosed and fossilized vertebræ, with a long and rather flattened bone attached to one side, the examination of which left a conviction of their agreement in general form and characters with the supposed sacral vertebræ and iliac bones of the Iguanodon in the British Museum. The following is the description of this sacrum of the Iguanodon given in the part of my 'Report,' published in 1841, where it is

* 'Report,' 1841, pp. 126, 127.
† Ib., p. 133.
‡ 'Report, Brit. Foss. Rep.,' 1841, p. 203.
§ 'Hist. Brit. Foss. Reptiles,' 4to, 1850, p. 136.

compared with the sacrum of the *Megalosaurus*, which I had about the same time determined:

"This instructive specimen consists of five vertebræ anchylosed together by the articular surfaces of their bodies, and by their spinous processes, which seem to form a continuous thick median ridge of bone. The articular extremity of the terminal sacral vertebra is very slightly concave and subcircular, measuring 3 inches in both vertical and transverse diameter. The bodies of the vertebræ are compressed at their middle part, and broader below than in the dorsal region, and concave in the direction of their axis, the concavities being separated by the broad prominent convex transverse ridges formed by the anchylosed and ossified intervertebral spaces. The contour of the under part of the sacrum thus forms an undulating line. The lateral and inferior surfaces are separated by a more angular prominence of the centrum; the under surface is less convex transversely, and the whole centrum is shorter in proportion to its depth and breadth, than in the *Megalosaurus*. The neurapophyses present the same remarkable modification in regard to their relations to the body of the vertebra as in the *Megalosaurus*, having shifted their position from the upper surface of a single centrum to the interspace of two, resting on proportions of these, which are more nearly equal, as the vertebræ are nearer the middle of the sacrum. The nerves were compelled, therefore, to escape from the spinal canal over the body of the vertebra, more or less near its middle, and impress the upper surface there with a smooth canal. The strong, vertically compressed, transverse processes, or sacral ribs, rise from the bases of the neurapophyses, and their origin extends upwards upon the spine, and downwards upon the sides of the contiguous vertebral bodies and intervertebral space: in the specimen described they are firmly anchylosed to all these parts, extend outwards, and expand to their extremities, four of which meet, join, and form an elongated tract of varying breadth, to which the ilium is firmly attached.

"The length of the largest penultimate transverse process was 5 inches 8 lines, its vertical breadth at the middle 3 inches, its thickness here 1 inch. The adjoining (last) transverse process was 5 inches in length; the interspaces of the transverse processes equalled from $2\frac{1}{2}$ to 2 inches. The sacrum increases in breadth posteriorly; its transverse diameter, including the anchylosed ilia taken at the posterior part of the acetabulum, is 13 inches, at the anterior part of the sacrum only 8 inches.* The proportion of the spine thus grasped, as it were, by the iliac bones, which transmit the weight of the body upon the thigh-bones, corresponds with the mass which is to be sustained and moved; and the size and structure of the sacrum indicate, with those of the femur and tibia, the adaptation of the present great herbivorous Saurian for terrestrial life," p. 130.

I looked forward to the more detailed description, with illustrative figures, of this unique specimen, when further worked out, as being likely to form one of the chief

* The true anterior limit of the sacrum is defined by this admeasurement.

novelties, and most important additions, to be submitted to the readers of my 'History of British Fossil Reptiles,' and other friends and cultivators of geology, in the forthcoming Sections of that work, of which the 'Reports' to the British Association, in 1840 and 1841, were designed, and known, to be the basis.

In some particulars I have been aided, and in a few illustrations anticipated, by the labours of zealous contemporaries. Two associated authors, taking advantage of the indications given in my 'Report,' obtained Mr. Saull's permission to examine the sacrum of the Iguanodon which I had discovered, and had a drawing taken of it, which they published in the 'Transactions of the Royal Society,'* confirming, in the main, my description, but describing an attached lumbar vertebra, as a sixth sacral one.

As the characters of the order *Dinosauria* were mainly founded on this specimen four plates have, in this Section of the 'History,' been devoted to the illustration of its remarkable structure.

Plate 8 gives a view of the under surface, of half the natural size in linear admeasurement.

The last of the lumbar series, L, upon the interspace between which and the first true sacral vertebra the neural arch of that vertebra, *n* 1, Pl. 9, has advanced, has thereby become confluent with the sacrum proper, characterised by the junction of its transverse processes with each other, and with the iliac bones. The confluent lumbar vertebra has a much broader centrum or body, L, than that of the contiguous sacral vertebra, especially at its middle part, which presents a subquadrate transverse section, the sides being vertical, excavated near the neurapophysis, and meeting the under surface at a right angle: the under surface is convex transversely, especially at its middle part, concave longitudinally. The anterior articular surface is quadrate, with the angles rounded off, and is broader than it is deep: it is slightly convex vertically, flat transversely, except near the periphery, which is convex: some remains of its water-worn and mutilated neural arch, showing the normal relation of its piers to the centrum, and its partial anchylosis to the advanced neural arch of the first sacral vertebra, are shown at *n n*, fig. 1, Pl. 11: the antero-posterior extent of the piers is short; the neural interspace between them and those of the first sacral vertebra is wide.

The body of the first proper sacral vertebra, *s* 1, Pl. 8, differs from the foregoing by its sudden decrease in transverse diameter, especially at its middle part, the sides being concave lengthwise, and with the under surface compressed and produced into a low ridge. In consequence of the advanced position of its neural arch, the first pair of sacral nerves pass over the upper surface of the centrum about one third from its hinder end, and deeply groove that surface in their passage; the fore part of the advanced arch of the succeeding vertebra rests upon and has coalesced with the expanded hinder end of the first sacral vertebra. The transverse processes of this

* 'Philosophical Transactions,' 1849, p. 275, pl. xxvi.

vertebra, which consist of short pleurapophyses, *pl* 1, have been advanced, like the neural arch, to the interspace between the first sacral and last lumbar vertebræ, and have coalesced with both; the major part of the expanded head of the short and strong sacral rib being fixed to the sides of the expanded anterior end of its own centrum: after becoming slightly constricted, the ribs expands, like the overlapping cervical ribs in the crocodile, in the direction of the axis of the body, but the sacral ribs more firmly unite their portion of the vertebral column together by becoming confluent at their expanded extremities. Almost the whole upper surface of the short sacral rib has coalesced with a strong, vertically developed, antero-posteriorly compressed, diapophysis, *d* 1, Pl. 9. These processes are continued outwards from the whole side of the neural arch, and form a series of strong transverse ridges, *d* 1—*d* 5, Pl. 9, progressively increasing in length to the fourth, *d* 4; the fifth, *d* 5, being of nearly the same length as the fourth. The neurapophyses extend forwards and backwards beyond the base of the diapophyses, and coalesce with each other and with the centrums, so as to convert the interneural outlets for the nerves into foramina. The neural spines, probably short in comparison with those in the dorsal region, and apparently more or less blended together to form a continuous ridge, have been broken or worn away to their bases, which are indicated by the letters *n* 1—*n* 5, in Pl. 9. The bodies of the second, *s* 2, Pl. 8, and third, *s* 3, sacral vertebræ are compressed, and continue to present the carinate inferior surface; that of the fourth sacral *s* 4, and fifth sacral *s* 5, progressively expand, and are convex beneath. In the first to the fourth sacral, inclusive, the sides of the centrum present a rounded depression a little behind their middle, the neural arches of the second, third, and fourth sacral vertebræ rest two thirds upon their own centrum and one third upon that in advance, dipping wedgewise into the interspaces of the centrums as they cross from one to another: the neural arch of the fifth sacral, like that of the first, rests in a larger proportion upon its own centrum, above which its piers meet, leaving a triangular neural surface before and behind their junction. The posterior articular surface of the body of the last sacral vertebra is shown in Pl. 11, fig. 2, *s* 5; it is slightly concave; the upper surface of the centrum above this end, and for about one-fifth of its length, Pl. 10, fig. 2, *s* 5, is free, the neural arch of the first caudal vertebra having resumed its normal position in regard to its centrum. The posterior zygapophyses, *z' z'*, Pl. 9 and Pl. 11, are in part preserved in the last sacral vertebra; the degree of diminution of the neural canal, as it extends, with partial expansions, through the sacral series, may be seen by comparing fig. 1 with fig. 2, in Pl. 11. The coalescence of the pleurapophyses and diapophyses circumscribes a series of four progressively expanding vertical canals on each side of the sacrum, the lower outlets of which are shown in Pl. 8, and the upper ones, *o, o, o, o,* in Pl. 9: the nervous foramina, in the interspaces of the neural arches, open into these canals. There has been a tendency to ossification in the fascia extended between the upper borders of the strong boundaries of these foramina, of which the evidence remains, at *f,* Pls. 8 and 9,

in a thick plate of bone, extending partly over the upper outlet of the second foramen. The coalesced extremities of the fourth and fifth sacral ribs have been broken away on the left side. These coalesced extremities form a continuous tract of bone, *pl* 1′—*pl* 4′, Pl. 8, with a flattened outer surface, slightly concave lengthwise, to which the iliac bone is attached, and has remained attached probably through partial confluence on the right side of the present specimen. The organic architecture of this part of the vertebral column of the ancient gigantic reptile cannot be sufficiently admired in reference to the due strength of the part thereby attained.

The pressure transmitted by the thigh bones upon the iliac bones is resisted, and is transferred by the strong vertical buttresses, formed by the modified and coalesced pleur- and di- apophyses, upon the bodies and neural arches of the sacral vertebræ; but, by the altered relative position of the neural arches and pleurapophyses, the weight transmitted by one pair of buttresses does not bear exclusively upon a single vertebral centrum, but is divided equally between two centrums. In the young and perhaps more active Iguanodon, prior to the general anchylosis that afterwards pervades this complex mass, the further advantage of a certain elastic yielding of the parts must have been gained, by the implantation of the piers of the neural arch, and the heads of the short, buttress-like ribs, upon or over the joints between the vertebral bodies. A like advantage is gained by the same modification, in regard to the position of the neural arches and ribs, in the vertebræ of the carapace of the Chelonian reptiles, and in the sacral vertebræ of the Ostrich; the structure of the latter is interestingly analogous to that of the same part of the spine in the extinct Iguanodon.*

A considerable proportion of the right iliac bone remains attached to the sacrum of the Iguanodon above described. It is a strong, elongated, subtriedral bone, Pls. 8, 10, 62′—62″ firmly adherent by an inner flattened surface to the confluent expanded ends of the five sacral ribs, *pl* 1—*pl* 5. The outer surface is divided into two facets by a strong longitudinal ridge, for the attachment of some of the powerful muscles of the hind limb, and a second short, oblique, almost vertical, ridge, divides the bone into an anterior and a posterior portion. The anterior portion is again subdivided into a thick, strong, acetabular portion 62—62, forming the upper part of the cavity for the hip-joint, and a more slender portion extending forwards as far as the anchylosed lumbar vertebra, and terminating in an obtuse point, 62′. The hinder portion of the ilium, 62″ is extended backwards beyond the surface of attachment to the sacral ribs, and probably terminated freely, as in most Lacertian reptiles; but the extremity of this part has been broken off. The chord of the acetabular arc or concavity measures 8 inches. The major part of the acetabulum was contributed, as in most modern lizards, by the ischium and pubis. Upon the whole, the structure of the ilium accords more with the Lacertian than the Crocodilian type of the bone.

* See my 'Archetype of the Vertebrate Skeleton,' 8vo, 1848, p. 159, fig. 27.

With the foregoing knowledge of the complex structure of the sacrum of the Iguanodon, the peculiarities of detached parts of those modified vertebræ become intelligible, and prove to be such as they were originally surmised to be.*

Detached bodies of the Sacral Vertebræ of the Iguanodon. Pl. 12. Nat. size.

As such parts, especially the centrum or body, are not unfrequently found separated from the rest of the skeleton of immature individuals, it has appeared desirable to subjoin a description of the most common of these parts.

No. $\frac{127}{2127}$, Mantellian Collection, in the British Museum, is the centrum of a sacral vertebra of a sub-quadrate form, with a broad and flattened inferior surface, Pl. 12, fig. 3, slightly concave lengthwise. The upper surface, fig. 4, is excavated by a wide and moderately deep canal, indicating the unusual size, for Reptiles, of the sacral portion of the spinal chord. The anterior, *n*, and posterior, *n'*, parts of the sides of this centrum, fig. 1, are raised, so as to form projecting sub-triangular rough articular surfaces, continued upon the margins of the neural canal, evidently for the attachment of the neurapophyses and the heads of the strong sacral ribs. The interspace of these anterior and posterior neurapophysial surfaces is formed by a smooth oblique groove, *o*, figs. 1, 4, connecting the smooth surface of the spinal canal with that of the free lateral surface of the vertebra, and indicating the place of exit of the sacral nerves: such outlet is necessarily in this unusual situation, because the holes of conjugation, as they exist in other vertebræ showing the ordinary position of neural arches, have here been obliterated by the impaction of the bases of the neurapophyses between the contiguous extremities of the bodies of the sacral vertebræ.

The anterior and posterior articular extremities of the present interesting fossil equally bespeak the peculiar character of the sacral vertebræ of the *Dinosauria*. They are impressed by coarse straight ridges and grooves radiating from near the upper part of the surface, fig. 2, like those on the corresponding part of a cetaceous vertebra when the epiphysial articular extremity is removed. These inequalities are here, doubtless, preparatory to that anchylosis by which the sacral vertebræ are compacted together in the mature Dinosaurs.

	In.	*Lines.*
The length of this vertebral body	2	10
The height	2	6
The breadth of anterior articular end	3	0
The breadth of middle part	2	2
Antero-posterior diameter of anterior costal surface	1	7
Antero-posterior diameter of posterior one	1	0

* 'Report on Brit. Foss. Reptiles,' 1841, p. 130.

	In.	Lines.
Breadth of spinal canal	1	5
Breadth of canal of sacral nerve	0	4

From its separated condition, the body of the sacral vertebra here described must have belonged to a young Dinosaur of a size far exceeding that of the *Hylæosaurus.* It is obviously very distinct in form from the sacral vertebræ of the *Megalosaurus.* No other reptile than one belonging to the order, characterised by the peculiar structure of the sacrum already described, could have yielded a detached vertebral centrum with the remarkable modifications of the one under consideration. The modifications detected in the entire sacrum of the *Iguanodon* in Mr. Saull's collection, justify the reference of the vertebra above described to the sacrum of a young *Iguanodon,* and it was probably the fourth of the series.

Caudal Vertebræ of the Iguanodon. Pl. 13. One fourth the nat. size.

The typical vertebræ of this region—those, viz., with hæmapophyses—are distinguished by the single hæmapophysial surface at each end of the narrow inferior surface of the centrum. The sides of the centrum are flat, or even slightly concave in the vertical direction, though less so than in the antero-posterior direction. In a caudal centrum, for example, in the Mantellian Collection, measuring 4 inches in length, and 5 inches 4 lines in depth at the middle of the side, if a pencil be laid vertically along that part, an interval of between 1 and 2 lines separates its middle part from the bone. Those equally great Wealden vertebræ which, on the contrary, have the middle of the side of the body prominent, and the lower half only converging towards the under surface, are from the tail of the *Cetiosaurus.* The posterior terminal articular surface is rather more concave than in the dorsal vertebræ; but the difference is by no means so marked as in the plano-concave vertebræ of the *Cetiosaurus.* The diapophyses* Pl. 13, *pl d,* of the anterior caudal vertebræ are comparatively short, but strong and are continued from the base of the neurapophysis, or from the contiguous part of the centrum, or from both parts.

The hæmapophyses, or chevron bones, Pl. 13, *h,* are not anchylosed to the centrum, but articulate with two contiguous vertebræ, crossing, and being somewhat wedged into,

* This process, in a certain proportion of the caudal series, is of the nature of a pleurapophysis, being developed from a distinct centre, and articulated, in the young Iguanodon, as in the young Crocodile, by suture to the rest of the vertebra. In succeeding vertebræ the homologous part is an exogenous process, which gradually subsides to a ridge, where it is of the nature of a diapophysis; and under such name, with the above explanation, it seems to me most convenient to distinguish the transverse process of the caudal vertebræ.

the inferior interspace of those vertebræ; in two of the caudal vertebræ of the Maidstone Iguanodon, there are two closely approximated hæmapophysial surfaces, as shown in Pl. 5 (*Dinosauria*); but in general the hæmal arch articulates with a single oblique triangular surface on each of the contiguous extremities of the co-articulated vertebræ, as in Pl. 14; the hæmapophyses being here confluent at their vertebral as well as at their distal extremities.

A caudal vertebra exhibiting this modification, in Mr. Holmes's collection, measures, in the vertical diameter of the articular surface, 4 inches 9 lines; in its transverse diameter, 4 inches 6 lines; the breadth of the inferior surface of the vertebra is 3 inches 3 lines. The interspace between the anterior and posterior hæmapophysial surface is 9 lines; it is concave in the axis of the vertebra. The diameter of the spinal canal is reduced in this vertebra to 9 lines. The transverse processes are of very small size. The spinous process is broken off. We have seen that those of the sacral vertebræ appear to have been short. There is reason to think that the spinous processes increased in length for a certain distance as they receded from the sacrum, and then diminished. Thus, in a caudal vertebra (No. $\frac{130}{2130}$, Mantellian Collection, Brit. Mus.), evidently anterior in position, by its size, by its oblique processes, and by the place of development of its transverse processes from the base of the neural arch, the spinous process is 5 inches in height, while in the six caudal vertebræ preserved in natural sequence and relative position in the Mantellian Collection, the spines are more than double that height, Pl. 13. That the vertebra (No. $\frac{130}{2130}$) is not a more posterior caudal vertebra from a larger Iguanodon is shown by the relative thickness, as well as position, of its transverse processes, as compared with the six caudal vertebræ above mentioned, for their transverse processes sensibly diminish in every diameter, and especially in vertical thickness, from the first to the sixth; and, moreover, it is evident that, in this short series, the spines decrease in height both forwards from the third, as well as backwards, but more so in the latter direction. Thus the spine, *ns*, of the first of these vertebræ is 14 inches high, of the third 15 inches, and of the sixth 13 inches. These spines increase in breadth toward their summits, which are truncated, and in contact with each other, partly from this expansion, partly from the posterior ones being slightly bent forwards. One cannot witness this change of character in so short a segment of the tail without a conviction that this appendage must have been relatively shorter than in the Iguana.

The first spine, besides being somewhat shorter, is more rounded off at its anterior margin than the third, a difference which is still more obvious in the detached caudal (No. $\frac{130}{2130}$) above described; but above its origin a thin trenchant plate is extended for a short distance from the middle of the anterior margin: this character, which calls to mind one that is present in a greater proportion of the vertebral column in the Crocodilians, is more strongly developed in the second and third vertebræ. The neurapophysial suture is more nearly obliterated in the sixth than in the first of this

instructive series, or in the more anterior and detached caudal vertebræ. The following are the dimensions of the detached anterior caudal (No. 1), and of the first (No. 2) and last (No. 3) of the series of six:

	No. 1.		No. 2.		No. 3.	
	In.	*Lin.*	*In.*	*Lin.*	*In.*	*Lin.*
Antero-posterior diameter of centrum	2	8	2	8	2	7
Vertical diameter of articular surface	3	6	3	3	2	6
Transverse diameter of articular surface	3	5	3	2	2	6
From under part of centrum to upper end of posterior zygapophysis	5	6	5	8	4	0
From upper end of posterior zygapophysis to the summit of spine	5	0	14	0	10	6
Antero-posterior diameter of base of spine	1	3*	1	7	1	4
Antero-posterior diameter of summit of spine	2	0	2	2	2	6

The chevron bones, of which three are preserved in the slab containing the six caudal vertebræ, Pl. 13, *h*, *h*, exhibit the perforated character, ib. H, which distinguishes them from those of the *Cetiosaurus* and of all existing Crocodiles and Lizards, not excepting the Iguana, in which the hæmapophyses are anchylosed at their distal or spinal end only, and remain separate and articulated to two distinct surfaces, at their proximal ends. The length of the superior and inferior vertebral spines, and the shortness of the transverse processes, prove the form of the tail to have been flattened laterally, and of great breadth in the vertical direction, at its basal portion at least.

The bases of the neurapophyses, *n*, *n*, are nearly co-extensive lengthwise with the centrum, *c*, and expand transversely so as nearly to meet where they rest upon the centrum, but they do not quite circumscribe the neural canal. They contract rapidly in antero-posterior extent, forming the notches of the conjugational foramina, or nerve-outlets, of which the posterior notch is the deepest.

Detached Caudal Vertebra of the Iguanodon. Pl. 14. Two thirds the nat. size.

The characteristic and well preserved caudal vertebra obtained by Mr. G. B. Holmes, from the Stammerham quarry of Wealden Stone, near Horsham, Sussex, is represented in different points of view in Pl. 14, two thirds the natural size. Fig. 1 gives a side view, showing the slightly concave, almost flat, surface of the side of the centrum; these lateral surfaces converge towards the under surface, the anterior and posterior angles of which are, as it were, truncated for the articulations, *h* and *h'*, of the confluent bases of the hæmapophyses; the diapophysis, *d*, springs out from near the back part of the vertebra, about the line of suture of the centrum *c*, and neural

* The anterior basal ridge of this vertebra is broken away.

arch *n*; the base of this arch equals about two thirds of the antero-posterior extent of the centrum to which it is attached, a little nearer the anterior than the posterior end. The arch sends forwards a pair of long zygapophyses, *z*, whose articular surfaces look inwards and a little upwards; a low ridge traverses two thirds of the summit of the arch, fig. 2, from the hinder third of which springs the neural spine, *n s*, which slightly gains in antero-posterior extent as it rises: but its summit is broken away: the posterior zygapophyses *z'*, fig. 1, project from the back part of the base of the spine: their articular surfaces look outwards and a little downwards.

The figure 2, of the vertebra, viewed from above, shows the form and extent of the summit of the neural arch, which is rarely preserved in fossil vertebræ. Fig. 3 shows the anterior, and fig. 4 the posterior, surface of the vertebra; the articular ends of the centrum are very slightly and irregularly concave, with the margin thickened and rounded off. The under surface of the centrum, fig. 5, is characterised by a median groove or channel between two parallel ridges which extend from the anterior *h* to the posterior *h'* hæmapophysial surfaces. Of these the posterior one is the largest.

The neural canal, figs. 3 and 4, *n*, is contracted; its area is a full transverse oval.

With respect to the terminal caudal vertebræ in which diapophyses and hæmapophyses have ceased to be developed, no specimen of Iguanodon has yet been discovered in which any such vertebræ have been so associated with the rest of the skeleton as to enable the conscientious observer to determine their character as unequivocally belonging to the Iguanodon. Two vertebræ, from the Wealden, near Battle, in the Museum of the Royal College of Surgeons, in which the diapophysis has subsided to a longitudinal ridge, crossing the upper third of the centrum in the smaller specimen, have been described in my 'Catalogue of the Fossil Remains' in that Museum, 4to, vol. ii, p. 25, as probably belonging to the Iguanodon; for it is most probable that the typical form of the body of the Iguanodon's vertebræ is modified or lost in such terminal and rudimental vertebræ; but as these are, in every case, the least characteristic bones of an extinct animal, their loss is of the least consequence, and any positive affirmation regarding them, on imperfect evidence, becomes the more gratuitous.

Tympanic Bone of the Iguanodon. Pl. 15. Nat. size.

Of the bones of the head of the Iguanodon, the characteristic one above named, a fragment of the upper jaw, and a larger proportion of the under jaw have been brought to light: the portions of the jaws, at least, are demonstrably those of the present species of herbivorous reptile, by the teeth which they contain: the great Cetiosaur and Streptospondyl may possibly have afforded the specimen figured in Pl. 15, which was

discovered in Wealden calcareous sandstone, and which, in the Mantellian Catalogue of the Fossils purchased by the British Museum, is assigned to the Iguanodon.

A reptile with vertebræ and ribs resembling in their chief characters those of the amphicælian Crocodiles, and with distinctive peculiarities, in which the Lacertians by no means participate, might reasonably be conjectured to resemble the Crocodiles in the form of the tympanic bone; and if the reptile in question used its teeth for masticating hard vegetable substances, we might with more reason expect that the bony pillar, supporting the lower jaw, should be firmly and immoveably fixed through its whole length, like the tympanic bone of the Crocodilians, and not be loosely suspended to the skull by a single extremity, as in the Iguana and other Lacertians. A very remarkable bone, discovered in the Tilgate strata, figured by Dr. Mantell in the 'Geology of the South-east of England,' pl. ii. fig. 5, the resemblance of which to the "os quadratum," or tympanic bone of birds, was first suggested by Dr. Hodgkin, is assigned to the Iguanodon by Dr. Mantell. He describes it "as forming a thick pillar or column, which is contracted in the middle, and terminates at both extremities in an elliptical and nearly flat surface." In the Iguana and other reptiles the lower end of the tympanic bone is terminated by a convex trochlea, which is received into a corresponding cavity in the lower jaw; and it may be asked:—Is the modification of the bone in question, assuming it to belong to the Iguanodon, indicative of a peculiarity of the joint of the lower jaw as remarkable as the structure of the teeth, and correlated to their masticatory uses? "Two lateral processes, or *alæ*," Dr. Mantell proceeds to state, "pass off obliquely, and are small in proportion to the size of the column; on placing these bones beside the os tympani of an Iguana, we at once perceive that the relative proportions of these parts are reversed; for in the recent animal the pillar is small and the lateral processes large. From the great size of the body of the fossil, and the extreme thinness of its walls, the *tympanic cellulæ* must have been of considerable magnitude, and have constituted a large portion of the auditory cavities. Pl. ii. fig. 1, (fig. 5 is meant,) accurately represents the most perfect specimen in my cabinet; it is 6 inches high, and 5½ inches wide at the longest diameter of the extremity of the body. It exceeds in magnitude the corresponding bone of the *Mosasaurus*, and is fourteen times as large as the same bone in an Iguana 4 feet long." Tab. X, p. 306.

After a careful inspection of the specimen, as it now may be seen at the British Museum, I have come to the conclusion that both extremities have been abraded or fractured: and that the form of the articular surface is not unequivocally demonstrated at either end. The parts described as "two lateral processes" appear to be the two piers *a*, *c*, of the auditory arch of the tympanic, which arch is composed of a broad thin plate of bone, and surrounds the "foramen auditorium externum," *e*, which is of a narrow oval form. Although the shape of this bone indicates that it was much less susceptible of movement than the tympanic bone usually is in Lacertian reptiles,

there is no appearance of a sutural attachment in its longitudinal extent, with a parallel and co-extensive squamosal bone, as in the Crocodilia: the points of connection seem to have been restricted to the two expanded extremities.

Lower Jaw of the Iguanodon. Plates 16, 17, 18. Nat. size.

At the beginning of the year 1848, Mr. George B. Holmes, of Horsham, obtained from the Stammerham stone-pit, or quarry, of Wealden, near that town, the right ramus of the lower jaw of a young Iguanodon, which is figured of the natural size in Plates 16 and 17.

The accurate and beautiful drawings made by his daughter, Miss G. M. Holmes, from which these plates are engraved, were most liberally transmitted to me, at that time, for description. Learning, however, from Dr. Mantell, when I was about to communicate that description to the Geological Society, that he also had just received from Captain Brickenden, of Warminglid, Sussex, the lower jaw of a larger Iguanodon which he was desirous to describe for the Royal Society of London, I declined to use the materials with which Mr. Holmes had favoured me, until Dr. Mantell's observations had appeared. His Memoir was accordingly published in the 'Philosophical Transactions,' Part II, 1848.

The most remarkable conclusion to which the author of that Memoir arrived, after a study of the above materials, was, that the Iguanodon had been endowed, not only with fleshy or muscular lips,* hitherto believed to be the peculiar characteristic of the mammalian class amongst air-breathing vertebrate animals, but with such lips greatly developed.†

The correlation or association of such muscular and sensitive appendages to the jaws with the necessity of deriving lacteal nourishment by the act of suction, during the infancy of the animal, has hitherto been so constant and exclusive in the air-breathing vertebrates, that a transition from the Reptilian to the Mammalian class, by the conjunction of fleshy lips with a scaly skin and cold blood, would be a most unexpected and extreme exception to one of the best established generalizations in Comparative Anatomy.

I shall, first, give a description of the portion of jaw from Stammerham, then compare it with the larger jaw obtained from Tilgate Forest, and finally endeavour to

* "The great size and number of the vascular foramina, &c., indicate the great development of the integuments and soft parts with which the lower jaw was invested." Phil. Trans. 1848, p. 197.

† "The sharp ridge bordering the deep groove of the symphysis, in which there are also several foramina, evidently gave attachment to the muscles and integuments of the under lip; and there are strong reasons for supposing that the latter was greatly produced, and capable of being protruded and retracted, so as to constitute, in conjunction with a large fleshy prehensile tongue, a powerful instrument," &c., p. 197. The author proceeds to infer from "the edentulous and prolonged symphysis, and the great development of the lower lip and the integuments of the jaws, as indicated by the number of vascular foramina, a striking analogy to the edentata." Ib., p. 198.

deduce such conclusions as to the nature of the soft parts that covered the lower jaw, as the characters of that bone may legitimately sustain.

The subject of Plates 16, 17, is the dentary piece of the right moiety or ramus of the lower jaw. It is chiefly remarkable for the straightness and parallelism of the upper, *a b*, and lower, *c d*, borders, for the portion which the dentary piece contributes to the suddenly rising coronoid process, *f*, and for the abrupt slope downwards, at an angle of about 45°, of the short, edentulous, compressed anterior part of the bone, *b*, to the shorter symphysis, *e*, *d*, fig. 1; which latter part of the bone projects a little below the lower level of the ramus. The exterior surface of the ramus is, vertically, a little concave where it forms the alveolar wall, and then becomes moderately convex to the thick and rounded lower border, Pl. 17, fig. 4. A few foramina, *g g*, fig. 1, open at irregular intervals, in a longitudinal series, upon the concave part of the outer surface of the ramus, from 5 to 6 lines below the alveolar border; and a few foramina occur parallel with the sloping border, *b c*, at a similar distance from it. The general surface of the bone on the outer side of the jaw is smooth, but becomes more irregular near the symphysis; it presents several lines of fracture, but rises to form the coronoid process, *f*, without any trace of the suture which separates the coronoid from the dentary piece in the jaw of the Iguana. The relative position of that suture, indeed, to the termination of the dental series, in the Iguana, is such that the suture could not be repeated in the Iguanodon, so as to include the coronoid process, because the dental series is continued backward along the inner side of the base of that process, 18, fig. 2. In the form, extent, and direction of the coronoid process, it closely resembles that of the Iguanodon, at least as regards so much of the process as is contributed in fossil by the dentary piece. If its extent were added to by a true coronoid element articulating with it behind, it would resemble the broader coronoid of the *Cyclodus* and *Varanus*. The presence of the process, though formed in an unusual way in the Iguanodon, gives the jaw a lacertine character, and makes it differ in a striking degree from that of the *Crocodilia*. It remains to be seen, however, in more complete specimens, whether the coronoid piece actually contributes any share to the process, or whether it be restricted, as in the Crocodilian reptiles, to the inner surface of the ramus, bounding the fore part of the wide entry to the mandibular canal.

The inner side of the dentary element of the mandible of the Iguanodon, Pl. 16, fig. 2, displays, as in the *Lacertia* generally, the alveolar recesses, and such traces of the teeth themselves as may have been preserved, which in the present case are limited to a few more or less advanced germs of successional teeth, *k*, *l*. This aspect of the jaw shows that the dentition of the great extinct herbivorous reptile was of the "pleurodont"* type, as in the Iguana and many other modern lacertine genera.

* 'Odontography,' p. 240; the term signifies the attachment of the teeth to one side or parapet of an open alveolar groove.

Eighteen alveolar fossæ for the lodgement of the contracted sub-cylindrical bases of the teeth are exhibited in Mr. Holmes's specimen; but all the teeth that were fully developed and had occupied those semi-cylindrical depressions have been lost. Greater or less portions of the protruding summits of six successional teeth are seen below the alveolar grooves of the old teeth, and of so much larger size as indicates a more rapid growth of the young Iguanodon, than in modern reptiles. In the different proportions in which the young teeth are developed, may be discerned an illustration of the same law of preservation of an adequate proportion of an ever changing series of masticatory organs, which is illustrated by the condition of the dental series in many modern reptiles and fishes. The teeth marked *k, k, k,* for example, of which the summits of the crown have but just begun to be calcified, alternate with those marked *l, l, l,* fig. 2, Pl. 16, in which the crowns are more advanced. One may see by the size of these teeth that they are destined for work in a larger jaw than that of the young Iguanodon in which they are cradled; one may likewise discern the unfitness of the actual alveolar grooves for the reception and retention of the large successional teeth, and thence rightly infer that the bone grows and goes with the growth and disappearance of the teeth themselves; the alveoli of the shed teeth being progressively absorbed as the osseous bed of the new teeth rises along with them. The same concomitant growth of the jaw-bone and the teeth has long been recognised in the mammalian class, and is strikingly exemplified in the elephant, in which the large complex molars succeed each other from behind forwards.

The surface of the jaw below the alveolar groove is smooth, but is traversed by a deeper and narrower groove continued from the entry of the mandibular canal, *i,* forwards, just above, and nearly parallel with, the lower border of the ramus, becoming shallower and descending to that border as the groove, *d,* approaches the symphysis, *s*; the major part of this groove was probably covered by the splenial element, (opercular of Cuvier), in the entire ramus of the Iguanodon's jaw. Above the groove the inner surface of the dentary is slightly convex at its posterior half, and slightly concave at the anterior half. The edentulous, narrow, sloping margin of the jaw, *b, e,* has a slightly tumid roughness along its inner side, as if for the firm attachment of a callous covering in the recent animal. The actual symphysis of the jaw is about two thirds of an inch in extent, and a quarter of an inch in greatest depth, almost horizontal in position, but bent, with the concavity looking upwards; the inferior and anterior angle of the jaw, *d,* projects a little way beyond the fore part of the symphysis, and the back part of the symphysis is impressed with a longitudinal groove, fig. 2, *s,* parallel with, but above, the anterior end of the mandibular groove, *d.*

In the small extent of the mandibular symphysis the Iguanodon resembles the *Lacertilia,* and differs from the *Crocodilia,* even from the true crocodiles and alligators in which the symphysis is much less than in the gavials; but the position of the symphysis at the lower end of the anterior termination of the ramus, and the sloping

edentulous character of that part are peculiarities in which the Iguanodon differs from all known modern reptiles.

Another character by which the Iguanodon differs from modern lizards, and especially from the Iguana, is the contour of the alveolar plate viewed from above, as in fig. 3, Pl. 17; it is thus seen to describe a gentle but graceful sigmoid curve, convex inwards at its hinder two thirds, straight in the rest of its extent, or slightly concave inwards, as continued by the edentulous symphysis. In the Iguana the hinder four fifths of the alveolar plate is straight; it bends inwards to the symphysis of the jaw at its anterior part. The form of the thick rounded lower border of the jaw of the Iguanodon is shown at fig. 4, Pl. 17.

In the Iguana the mandibular groove runs nearer the base of the alveolar plate than the lower border of the ramus, and stops short before it has reached the middle of the dental series: in the Varanus the same groove extends from the anterior termination of the splenial piece along the lower border of the ramus as far as the symphysis; in regard to this groove, therefore, the Iguanodon resembles the Varanus and also the Cyclodus more than it does the Iguana. In the Crocodiles one sees only an oblong foramen at the fore-end of the splenial element. The inner plate or wall of the dentary bone in the Iguanodon bifurcates behind, as in most reptiles, where it articulates with the splenial, angular, and coronoid elements; the upper branch is shown at *h*, the lower one at *c*, fig. 2, Pl. 16. What may have been the length of the entire jaw, as completed by the splenial, angular, surangular, and articular elements, must remain conjectural, until either this part of the mandible, or an entire upper jaw with the tympanic part of the same cranium, may be discovered.

In the Iguana the dentary element forms about three fifths of the length of the lower jaw; in the Cyclodus it forms rather more than half, in the Varanus a little less than half of the lower jaw; in the Crocodile it forms more than two thirds the length of the jaw.

As the dentary piece in the Iguanodon itself contributes to the formation of the coronoid process, it is probable that the entire jaw may more nearly resemble the Crocodilian than the Lacertian type in the proportion of the ramus formed by the dentary element.

The length of the corresponding element of the lower jaw of probably a mature Iguanodon, now in the British Museum, Pl. 18, fig. 1, is 21 inches; its vertical diameter, in a straight line, where the alveolar wall is best preserved, is 4 inches, 7 lines, so that it is relatively deeper than in the younger Iguanodon, and this probably in reference to a deeper implantation of the large teeth of mature age, and to the greater strength of the jaw required for the more vigorous mastication at that period of life. The coronoid process, Pl. 18, *f*, being a part of the dentary bone, has also been preserved with the rest of that element in Capt. Brickenden's specimen, and shows the same abrupt curve upwards. The nervo-vascular foramina, *g*, *g*, are

more numerous than in the younger jaw, but are arranged, as in that jaw, along the outside of the alveolar wall, beginning near the base of the coronoid process, and extending down the edentulous sloping part of the jaw; their size is exaggerated in the figure given in the 'Philosophical Transactions,' and there is no particular anterior foramen, larger than the rest, and meriting, as in the mammalia, the name of "foramen mentale." The exterior marginal groove of the edentulous border is better marked in Capt. Brickenden's than in Mr. Holmes's specimen, but the alveolar wall has suffered more injury in the Tilgate specimen than in that from Stammerham; in the latter, indeed, it seems to be entire, and so much of the thin inner border is preserved as to show that there was not any internal alveolar wall co-extensive with the outer one. I cannot discern evidence of more than 18 dental depressions on the outer alveolar wall of the large lower jaw from Tilgate; the number, therefore, is the same as in the specimen from the younger Iguanodon, just as we find the same number of teeth in the same species of Crocodile at all ages of the individual, no additional teeth being added to the series from behind, like the true molars in the Mammalia, in the course of the change of dentition as the animal advances to maturity. So much of the inner surface of the dentary bone as is preserved entire in the Tilgate specimen, corresponds with the same portion in the younger specimen from Stammerham; no part is absolutely flattened: the part sustaining the upper division of the mandibular canal has been broken away.

If we pass now to the consideration of the inferences as to the nature of the soft or perishable teguments of the jaw, which are deducible from the characters of the bone itself, it may be first remarked, that the disposition of the vessels and nerves, supplying such teguments, differs according to their nature in different existing air-breathing vertebrate animals, and the jaw-bone exhibits corresponding differences in relation to such modifications of the mandibular vessels and nerves. To those who may not have ready access to Cabinets of Comparative Osteology, a glance at the plates of the well-known and widely distributed 'Ossemens Fossiles,' of Baron Cuvier, will show that the rami of the lower jaw in Mammalia usually present one large, rarely two or three, foramina, on the outside of each ramus at its fore-part; but that, in reptiles, as may be seen in the Crocodiles, Pl. 1; the Lizards, Pl. 16; the Tortoises, Pl. 11;* the nervo-vascular foramina are more numerous, smaller, and arranged, in a more or less linear series along nearly the whole extent of the outside of the ramus of the jaw.

The first modification relates to the concentration of the nervous and vascular influences upon thick, muscular, soft, sensitive, extensile and retractile lips, covering the jaws, and extending beyond their fore part, where such lips are most developed. The second modification relates to a more diffused and equable supply of the nervous and vascular, but especially the latter, influences, to salivary follicles opening along the

* The 4th edition, 1824, tom. v, pt. ii, is here cited.

alveolar parapet, and to rapidly worn and renewed horny scales covering the outside of the rami of the lower jaw. The like differences of the condition of the soft parts external to the upper jaw govern corresponding modifications of the nervo-vascular foramina of the bones of that part. It will be obvious, on the slightest reflection, that the horny scales or scutes covering the borders of the jaws in reptiles must be those that are subject to most abrasion, moistening, and other influences accelerating their decay; and in the living Saurians it may be generally seen that the marginal scales or scutes of the jaws exhibit the effects of such destructive influences contingent on their position. As these scales are more quickly worn away than those of other parts, so they are more rapidly renewed; their progress of growth is quicker, and their formative beds in the cutis have a greater supply of both vessels and nerves: the greater vascularity of this part of the integument is shown by injecting the head of a crocodile or lizard, and macerating away the cuticular scales. The labial muco-salivary follicles are arranged commonly in a linear series, and their orifices may be seen in a row along the narrow and shallow groove between the alveolar border and the scaly integument forming the margin of the mouth: these follicles, in most Saurians, perform the offices assigned to the more compact and localized salivary glands in Mammalia; and consequently require and exhaust a good supply of blood. The arteries emerging from the serial foramina resolve themselves each into a brush of small branches which are spent in the vascular matrices of the labial scales and on the secreting surfaces of the labial glands.

In the great Mosasaurus, as is shown in Pl. XVIII, of the 'Ossemens Fossiles,' of Cuvier,* the linear series of nervo-vascular foramina along the outside of the ramus of the lower jaw indicates plainly that such jaw was covered by a firm scaly integument protecting a long series of muco-salivary follicles, as in existing Saurians. In the great Megatherium and Mylodon the single or double large nervo-vascular outlets confined to the fore part of the mandibular rami equally attest the existence of fleshy and sensitive lips produced beyond the fore part of the jaw, and capable of being further protruded and retracted.

It needs only a comparison of the lower jaw of the Iguanodon with that of the Mosasaurus and of any recent reptile, and with that of the Megatherium and of any recent Mammal, to arrive at a correct conclusion as to whether the Iguanodon resembled the Saurians in the covering of its jaws, or presented the monstrous combination of mammalian lips with a reptilian skeleton.

I have only to add that the form of the anterior termination of the jaw of the Iguanodon is diametrically opposite to that of the Mylodon: in the former, the upper border slopes downwards and forwards at an angle of 45° to the straight inferior border; in the latter the inferior border bends upwards and forwards at nearly the same angle to the straight upper border. In the reduced figure of the lower jaw of

* Ed. 4to, 1824, tom. v, pt. 2.

the Iguanodon in Pl. XVII, fig. 4, of the memoir above quoted in the 'Philosophical Transactions' for 1848, the nervo-vascular foramina are not diminished in the same proportion as the jaw itself: they are accurately delineated both as to number and size, in Pl. 18, fig. 1, *g, g,* of the present Section. The angle, also, at which the two rami of the lower jaw are conjecturally united in Pl. XVII, 'Phil. Trans.,' 1848, is much too acute; and the restoration of the lower jaw in the Mantellian collection, British Museum, accordingly leaves a transverse space equalling little more than one half the breadth of the upper jaw, to the description of which I next proceed.

Fragment of the Upper Jaw of the Iguanodon. Pl. 18, figs. 2, 3, 4.

After the tympanic bone and lower jaw, the most instructive and intelligible part of the skull of the Iguanodon, as yet obtained, is a portion of the upper jaw, consisting of so much of the back part of the left superior maxillary bone, with the alveolar groove, as includes ten dental recesses, seven of which contain teeth. This specimen was washed out of the submerged Wealden deposits off Brook Point, Isle of Wight, and is now in the British Museum.

The alveolar groove opens widely and obliquely upon the inner and under aspect of the fragment, *a, a,* fig. 3: the outer side or parapet, fig. 2, is formed by the chief osseous mass with the outer compact wall of the jaw, fig. 4, *b, b*; this wall sends off from its upper and outer side a process, *m,* directed backwards and a little outwards, with the end broken and blunted by attrition, or water-worn; the bone is then continued backwards, slightly expanding in the vertical direction, and terminating in a point, *p,* also obtusely rounded by attrition subsequent to fossilization. Both this extremity and the malar process show unequivocal evidence of sutural surfaces upon their outer and upper side; that upon the malar process is oblong and depressed; that upon the upper and outer part of the hinder end of the maxillary is broad, oblique, and divided into two parts by a longitudinal elevation. Between this extremity and the malar process the canal, *c,* for the nerves and vessels of the upper jaw enters the substance of the bone, immediately above the deep rounded groove that divides the process from the body of the bone; a fossa is continued forwards above the canal, for an inch and a half, in advance of the entry of the canal, and continues the separation of the process from the body of the bone in that direction.

The smaller anterior end of this fragment is of a trihedral figure; the inner and under side is formed by the dental groove, the inner and upper side is flat; the outer side is slightly convex. At the angle where the last two sides meet there is a narrow sutural or fractured surface continued forwards from the sutural depression upon the upper part of the malar process. A transverse section of the anterior extremity of the fragment, fig. 4, taken through the foremost tooth, 1, and its successor, 2, shows com-

pact bone from three to four lines in thickness, forming the outer surface, *b*, *b*, and a similar layer from one to two lines thick, forming the inner surface, *i*, and increasing to near three lines in thickness, where it bends down to form the shallow inner boundary of the alveolar groove, *i*, *a*; the compact substance is not continued over the alveolar groove itself; the intermediate substance is an areolar osseous tissue, the meshes being most open along the inner and upper surface of the bone. The maxillary canal, *c*, exposed in this section is nearer the outer surface; it measures 14 lines by 8 lines in its diameters, sending off branches which perforate obliquely, outwards and forwards, the compact outer wall of the jaw. Of the three oval nervo-vascular foramina, *g*, *g*, preserved in the present fragment upon the outer surface, two are 4 lines, and the third 3 lines in long diameter; they are included in a space of 16 lines, are situate about an inch above the worn outer border of the alveolar groove, and are the last three of the series of such foramina. They correspond nearly in size and relative distance from the alveolar border with those at the back part of the similar series of nervo-vascular foramina in the lower jaw of the Iguanodon; and like them the obliquity of their course indicates the relation of the fragment to the anterior and posterior extremities of the jaw. The corresponding foramina are present on the same part of the bone in the more mutilated homologous portion of a dentigerous bone of the Iguanodon figured in Dr. Mantell's 'Memoir,' above quoted, Pl. XIX, and equally prove the part to which those orifices incline as they open outwards to be the anterior end of the fragment, and not the posterior end, as the anatomist conjectured of whose aid Dr. Mantell availed himself in the interpretation of this fragment.

The vertical extent of the slightly convex outer surface of the maxillary, in front of the malar process, in the present fragment, is 3 inches, but a portion has been broken away from the border, to which the smooth and flat inner surface of the maxillary converges as it ascends; it is possible, therefore, that the outer wall of the maxillary of the Iguanodon may have been continued relatively as high vertically as in the Iguana, Varanus, Tejus, and most other Lizards: anterior to this broken upper surface is a portion of a wide smooth depression, or of a canal laid open.

The alveolar groove, as it extends backwards, curves outwards, in the same degree as the alveolar groove does at the same part in the lower jaw, Pl. 17, fig. 3. The extent of the alveolar groove in the present fragment of the upper jaw is 8 inches; the antero-posterior diameter of the crown of the largest tooth is 1 inch; it seems to answer, therefore, to the posterior half of the dentary part of the lower jaw of the Iguanodon. The first tooth, 1, is a fully developed or old one, with its cement-covered base apparently continuous or confluent with the cancellous bottom of the groove, *a'*. The crown of the tooth, 2, which is about to succeed it, and which has in part undermined and excavated the old tooth, is on the inner and posterior side of its base; the crown of the new tooth is widely and deeply excavated, as shown in the section, fig. 4, 2, where the hollow base of the crown has suffered a slight fracture and displacement:

a thin layer of dentine has been formed beneath the enamel; the mineral matter now occupies the place of the original vascular pulp of the dental matrix. The flattened side of the crown of this tooth is turned towards the outer alveolar wall, the convex surface looks inwards and downwards; in the lower jaw the teeth, Pl. 16, fig. 2, *l*, *l*, have the reverse direction, as stated in Dr. Mantell's Memoir on the lower jaw, from Tilgate.* Next, behind the young tooth, 2, is the recess from which an old tooth has been expelled; and behind the recess is a fully formed crown of a tooth, 3, with the beginning of the fang, which tooth had come into use, but its grinding surface has been worn down by the rolling of the fragment after fossilization and extrication of the specimen from the matrix; a narrow recess follows this tooth, and then comes the fang and base of the crown of an old tooth, 4, partly undermined, and about to be pushed out by the crown of a successor, 5; next follows an empty recess; then the base of apparently a fully developed tooth, 6, the projecting crown of which has been broken away; close behind this tooth is the base of a narrower and smaller tooth, 7, followed by the recess for a similar sized tooth, which terminates the series.

We thus see that, as in the lower jaw of the Iguanodon and in the upper jaw of the Iguana and Tejus, the teeth decrease in size at the hinder end of the series; and that this end of the series in the Iguanodon inclines outwards, as does the same end of the alveolar series in the lower jaw, to which it was opposed.

As a similar portion of bone, recognised by Dr. Mantell as a "fragment of the upper jaw of an Iguanodon," when first discovered in 1838, in a quarry near Cuckfield, has been referred to the opposite end of the jaw, in the Memoir in which it is figured, 'Philosophical Transactions,' 1848, Pl. XIX, pp. 190, 191, with an appeal to the osteology of the recent Iguana, as confirmatory of that determination, I may be excused for concluding by a summary of the facts which seem to me to determine rightly the nature and relative position to the rest of the skull of the present very interesting part of the fossilized skeleton of the Iguanodon. The size of the teeth forbids the supposition that the fragment in question can have formed part of a pterygoid or palatine bone,—such a dentigerous bone, viz., as is shown in the skull of the Mosasaurus and, amongst existing Saurians, in the Iguana: both the shape of the pterygoid and the relative size of the teeth discourage the idea that the present fragment can be part of the homologous bone: it would be contrary to all known analogies to refer it to the palatine bone; and there remains, therefore, only the superior maxillary bone with which to compare it. Of this bone the specimen is evidently that part or extremity containing a natural termination of the alveolar groove; this is shown by the suddenly diminished size of the teeth and alveoli, and by the portion of bone, *p*, fig. 2, which is continued beyond the last alveolus.

The question next arises:—Does the fragment include the anterior or posterior end of the alveolar groove? In answer to this I may first remark, that the outer and inner

* Philos. Trans., 1848, p. 187.

sides of the fragment are determined by the relative depth of the walls of the alveolar groove, and by the relative position of the new and old teeth. In no pleurodont lizard is the deeper wall the innermost; and in no lizard or crocodile does the germ of a successional tooth appear on the outside of the base of the one it is about to succeed. The philosophy of Zootomy compels one to be guided by so great a number of observed instances, as is implied by the above generalized statement, as by a rule; and we know that the lower jaw of the Iguanodon conforms to that rule, by direct observation. In the upper jaw of the Iguanodon the successional tooth-germ is not situated directly on the inner side, but is also behind the tooth about to be displaced, at least in most of the specimens in the present fragment.

The extremity of the alveolar series, therefore, exhibited in the present fragment, must be either the fore end of the right maxillary bone or the back end of the left maxillary bone. The expansion and bifurcation of the bone, as it approaches towards the end of the alveolar series, are opposed to every analogy presented by the fore part of the maxillary in the Lacertian and Crocodilian reptiles. The foramina, grooves, and sutural surfaces become utterly unintelligible in this supposition; which is opposed, moreover, by the direction of the nervo-vascular outlets on the outer side of the bone, and by the curvature of the extremity of the alveolar series, as compared with the anterior extremity of that series in the lower jaw. In favour of the conclusion that the fragment in question is from the back part of the upper jaw, the expansion of the bone as it recedes from the triedral fractured end, *a*, *a'*, the direction of the nervo-vascular outlets, *g*, *g*, the altered direction of the alveolar groove, inclining, *e. g.*, outwards to be adapted to the hinder curve of the alveolar groove of the lower jaw, and the diminished proportions of the teeth at its obvious termination, all concur. And I may add that, supposing the Iguanodon, like the Iguana, to have had the dental series of the upper jaw prolonged forwards upon a premaxillary bone, the alveolar series of the maxillary would have been continued nearer to the end of the bone, and would have terminated more abruptly than it does in the present fragment.

Thus conducted to the conclusion that we have in the fragment in question the hinder part of the left superior maxillary bone, we have evidence that the Iguanodon differed (as, indeed, from the important differences in other parts of the skeleton might have been expected) from the Iguana and the Crocodiles, in having the alveolar end of the upper jaw produced backwards, beyond that outstanding backwardly inclined process, which gave attachment to the malar bone, such backwardly produced dentary end of the bone corresponding with that end, in the existing reptiles above cited, which articulates with the ectopterygoid ("os transverse" of Cuvier).

The dental series, thus brought more beneath the cranial part of the skull, would be more favorably placed for the operations of the masticatory muscles inserted into the lower jaw, and the backward prolongation of the dentary element, where it is developed into a coronoid process, is a departure from the ordinary reptilian structure

of the lower jaw, in itself significant of some correlative modification of the upper jaw. So far as the valuable fragment in question illustrates the nature of that modification, we discern in it an approximation to the mammalian type of the superior maxillary bone, subservient probably to a greater development of the homologue of the masseter muscle than is found in any recent reptile.

As the lower jaw of the *Iguanodon* does not contain more than 18 teeth in each ramus, it may be concluded that the portion of the upper jaw above described, supported at least one half of the dental series of the left side. The total length of that series in the skull to which such portion of jaw belonged must have been about 16 inches. The length of the alveolar tract, in the largest example of a ramus of the lower jaw yet discovered, Pl. 18, fig. 1, is 13 inches.

In a cranium of the *Iguana tuberculata*, which measures 2½ inches in length, the dental series occupies four sevenths of that length: according to the same proportions, therefore, the cranium of the Iguanodon, affording the above fragment of the upper jaw, would be 2 feet 4 inches in length. If the lower jaw of the Iguanodon exceeded the length of the cranium in the same proportion as in the Iguana, 2 feet 8 inches may be assigned to the total length of the skull of the Iguanodon, according to the evidences as yet obtained. But the unbiassed will feel that the rest of the structure of the Iguanodon, and especially of its teeth and vertebral column, differs in too great and important a degree from that of the Iguana to allow much confidence to be attached to the conclusions formed or suggested as to the Iguanodon, according to the osteology of the recent lizard, after which it has been called.

Teeth of the Iguana. Pl. 23. (Figs. 1—5, after Mantell, 'Phil. Trans.')

Respecting these characteristic parts of the great extinct Reptile, little need be added to the observations recorded in my 'Odontography,' in the 'Section on the Fossil Reptilia of the Cretaceous Formations,' pp. 269—272, and the excellent descriptions by Drs. Mantell and Melville, in the 'Philosophical Transactions,' for 1848.

Fig. 1, is a fully formed and moderately worn tooth of the upper jaw, showing the outer side; *a*, is the submedian primary longitudinal ridge, *b*, *b*, the accessory ridges, *c*, *c*, the lamello-serrated margins of the crown, of which the anterior is the longest; *d*, *d*, the compressed subquadrate fang. Fig. 1 *a*, gives a view of the fore part of the same tooth, showing the varying proportions of the two diameters of the crown and fang. Fig. 1 *b*, gives the form of the grinding surface of the crown; *a*, is the primary ridge on the enamelled side; *b* and *c*, the two facets produced by the attrition of two opposed teeth on the lower jaw.

Fig. 2. The outer side of an old tooth from the left upper maxillary bone, of

which the crown is much worn down by the action of the opposite teeth below, and the fang much absorbed by the stimulus of the growth of a succeeding tooth. *a*, the primitive ridge; *b*, *b*, the accessory ridges; *c*, the angle of the anterior border. Fig. 2 *a*, the inner side of the same tooth, showing the cavity produced by absorption at the base *d*. Fig. 2 *b*, the grinding surface of the crown; *b*, *c*, the two facets produced by the attrition of two teeth of the lower jaw.

Fig. 3. The inner side of a successional tooth of the right ramus of the lower jaw, in which the crown is fully formed, with the beginning of the fang, but has not come into use, and shows the lamello-serrated margin entire; *a*, the primary ridge; *b*, *b*, the secondary ridges; *c*, the anterior border.

Fig. 3 *a*. The outer side of the same tooth, showing the widely open pulp-cavity, *p*.

Fig. 4, shows the outer side of a tooth from the left ramus of the lower jaw, the crown of which had recently come into use; *c*, the anterior margin of the base of the crown; *d*, the contracted end of the fang. Fig. 4 *a*, is an oblique view of the enamelled inner side and posterior angular border, *c*, of the same tooth.

Fig. 5, the outer side, fig. 5 *a*, the inner side, of a tooth from the left ramus of the lower jaw, in which all the serrated part of the crown has been worn down in mastication, and a great part of the fang renewed by absorption: the grinding surface shows the two facets *b* and *c*, produced by the action of the two opposing teeth of the upper jaw, and also the inequality due to the more rapid yielding of the softer unenamelled vaso-dentine, forming the outer half of the crown.

Fig. 6. The inner side of the germ of a tooth of the lower jaw of a young Iguanodon, probably from near the anterior end of the series. This tooth shows only the primary ridge, and the entire serrated margin of the crown.

Fig. 7. The outer side of a fully-formed and slightly worn tooth, from the upper jaw of a young Iguanodon.

Fig. 8. A magnified view of a longitudinal section of the upper part of the crown of a slightly worn tooth of an Iguanodon, illustrative of the microscopic structure described, pp. 270, 271, of the Section II on 'Cretaceous Reptiles.' *e* is the thin layer of enamel which coats the outer side of the crown of the upper teeth and the inner side of that of the lower teeth; *d* is the hard or unvascular dentine, forming the corresponding half of the crown; *v* is the softer vaso-dentine, forming the inner half of the upper and the outer half of the lower teeth; *m*, the medullary or vascular canals; *c*, cement.

Fig. 9, is a transverse section of the outer part of an upper tooth, more highly magnified, of an Iguanodon, *d* the dentine, *e* the enamel. Fig. 9 *a*, a similar view of a transverse section from the inner half of the crown of the same tooth; *m*, the orifices of the medullary canals.

Bones of the Extremities of the Iguanodon.

These are remarkable for their superior development in proportion to the vertebræ of the trunk, as compared with the Iguana, the Crocodiles, and other existing Sauria. The scapular arch accords with the Lacertian type in being complicated with clavicles, and in the great breadth of the coracoid; but the scapula, in its length and simplicity, resembles more that of the Crocodiles than of the Lizards.

Scapula, Coracoid, and Humerus. Pl. 19. One third the nat. size.

The scapula, Pl. 19, figs. 1 and 2, is a long, flat, narrow bone, slightly bent backwards, gradually contracting in breadth and augmenting in thickness from its free extremity, answering to the base, *a*, to its articulated end, *d*, which suddenly expands and developes processes, *b*, *c*, before joining the coracoid, *f*.

These processes are two in number; one, *b*, is from the anterior border a little above the surface, *d*, for articulation with the coracoid; it is short and obtuse: the other, *e*, is still shorter, and comes off from the posterior border just above the articular surface, *c*, for the head of the humerus. The outer surface of the bone is slightly depressed between these processes, and becomes contracted beneath them where it forms the two articular surfaces, *d*, *c*, above mentioned.

The process, *b*, answers to the stronger and broader anterior process of the scapula of the Crocodile: the posterior process, *c*, seems to have no homologue in the modern Reptilia.

The scapula in the Amboina lizard, called *Istiurus*, sends backwards and upwards a process, but it is relatively longer than in the Iguanodon, and comes off higher up the scapula: the Psammosaurus and Grammatophora have no such process, and the entire scapula is much broader in proportion to its length. The scapula of the Iguanodon in general shape resembles that of the Crocodilia more than that of the Lacertian, but it is longer and more slender than in the Crocodile. The scapula, seen fractured across the femur in the Maidstone Iguanodon, Pl. 1, '*Dinosauria*,' Section II, 'Cretaceous Reptiles,' and figured in Dr. Mantell's Memoir, 'Phil. Trans.,' 1841, Pl. VIII, fig. 30, as an undetermined bone, repeats all the essential characters of the scapula so beautifully exposed, in natural connexion with the coracoid, in Mr. Holmes's specimen, figured in Pl. 19, fig. 1.

The coracoid, fig. 2, *f*, more closely accords with the Lacertian type of that bone: it is a sub-semioval plate, broader than it is long, with the middle of its straighter border produced and thickened, and divided into two articular facets; one, fig. 1, *f*, for the scapula, the other, *g*, for the humerus: this articular part or "head" of the coracoid is marked off by a short constriction or "neck" from the broad plate or

the "head," widens as it sinks, its dilated termination answering to a foramen at that part of the coracoid in the Iguana, Istiurus, and Grammatophora: a smooth rounded notch divides the back part of the head from the backwardly produced obtuse angle of the bone, fig. 2, *g*. There is no process extended forwards from the fore part of the "body" of the bone: a notch, fig. 1, *h*, which penetrates the bone at the fore part of scapular end of the bone, as in the Lacertians above named; the lower and inner border of the expanded body of the coracoid describes a full semi-oval contour, which, in Mr. Holmes's specimen, fig. 2, is broken by a short and narrow notch, entering about the middle of that border.

In the comparative simplicity of the coracoid of the Iguanodon we may discern an affinity to the Crocodilian reptiles, and in its degree of expansion an affinity to the Lacertian order: this bone, as well as some other part of the skeleton, manifesting the intermediate position of the herbivorous Dinosaur, and its adherence to a more general type of Reptilian organization, than the modern forms of Reptile present.

An articular portion of the coracoid, measuring 10 inches in diameter, and discovered in the Wealden of Tilgate forest, is preserved in the British Museum.

The chief mark of difference from the Crocodilian structure of the scapular arch, and of resemblance to the Lacertian type, is the presence of a distinct pair of clavicles, the form of which is well shown in the instructive collection of parts of the same skeleton of the Iguana, discovered by Mr. Benstead, in his Green Sand quarry, near Maidstone. The only other bones to which the long and slender ones, marked "clavicle," in Pl. 2 '*Dinosauria,*' Section II, 'Cretaceous Reptiles,' can be compared, are the thoracic ribs and the fibulæ. The presence of the fibula in the same block of stone, and its discovery in close proximity with the tibia and femur in the Wealden strata, satisfactorily prove that the present remarkable bone cannot have formed part of the hinder extremity. And since, in most recent lizards, the radius, which is the more slender of the two bones of the fore-arm, differs from the fibula in little more than in being somewhat shorter and thicker, there is still less reason for supposing the bone in question to have belonged to the fore arm.

The form of the ribs of the *Iguanodon* is well known; their characteristic proximal extremity, in the longer anterior pairs of thoracic ribs, is shown in Plate 7, and they become shorter and more curved as they advance from the middle to the anterior part of the chest.

Amongst the bones obtained by Dr. Mantell from the quarry-men of Tilgate forest, and submitted by him, in 1830, to the examination of Baron Cuvier, was one, 28 inches in length, now in the British Museum, which the great founder of Palæontology thought "might be a clavicle:"* portions of other homologous bones have been found, indi-

* This opinion is cited by Dr. Mantell in his 'Geology of the South-East of England,' 8vo, 1833 p. 308.

cating a total length of 3 feet. In a Memoir, communicated by Dr. Mantell to the Royal Society, and printed in the 'Philosophical Transactions' of 1841, the author dissents from the opinion of Cuvier; remarking, that, "In none of the skeletons of reptiles, or, indeed, any other animals to which he had access, are there any bones with which these fossils could be identified."* He regarded, therefore, the term clavicle as being manifestly inappropriate and liable to lead to misconception ,and proposed to distinguish the bone in question by the term "*os Cuvieri*, as the Cuvierian element of the pectoral arch of the Iguanodon."† From a reference to myself, in the same page, it might be supposed that I had concurred in this view of the introduction of a new element in the scapular arch of the Iguanodon; but at the time when I assisted Dr. Mantell in the comparison of the bone in question, I was not aware that he entertained any such view of it as was afterwards expressed in the Royal Society's Transactions. "In a very small lizard in the Hunterian Museum, Mr. Owen pointed out to me a bone attached to the coracoid and omoplate, that bore some analogy to the bone in question." The clavicle of the lizard alluded to (*Cyclodus nigroluteus*), bore sufficient resemblance, as I have before stated (Section II,'Cretaceous Reptiles,'p. 265), to the long and slender fossil under comparison, to confirm the conjecture of Cuvier; but it lent no support to the idea of the long and slender fossil in question being a peculiar superaddition to the Saurian skeleton. The bone is compressed, slender, and sub-trihedral at the middle part, expanded and flattened at the two extremities, bent with a slight double curve in a graceful sigmoid form. The broadest end, which, from the analogy of the Cyclodus lizard, must be regarded as the median or pectoral extremity, gives off two processes, the first appearing as a continuation of the thinner margin of the bone, twisted and produced obliquely downwards; the second process is given off nearer the expanded sternal end, towards which it slightly curves.

	In.	*Lin.*
The breadth of the expanded sternal end of a clavicle, 29 inches in length, is	3	7
The breadth of the scapular end	4	3
From this extremity to the base of the first process . . .	19	0
The breadth of the narrowest part of the shaft . , .	1	7

In the clavicles preserved in the Maidstone Iguanodon, the short pointed process is sent off at the angle where the shaft slightly bends as it expands into the sternal extremity; and the second process is a broad subquadrate flattened plate. In the Cyclodus lizard the clavicle is bent at an open angle, but nearer the middle of the shaft than in the Iguanodon; the known differences of form presented by the clavicles in the genera *Cyclodus*, *Istiurus*, *Grammatophora*, *Amblyrhynclus*, and *Iguana*, would have justified the expectation of some unexampled modifications of that variable bone in a great extinct Reptile belonging to a different order of the class.

* 'Phil. Trans.,' pt. ii, 1841, p. 138. † Ibid.

The most interesting and instructive information regarding the humerus of the Iguanodon, afforded by Mr. Holmes's discovery, in 1847, of that bone, associated with the scapula and coracoid, in the same block of stone, was its relative dimensions to the scapula and other bones of the skeleton. The bones, so discovered, are represented, two thirds of their natural size, in Pl. 19. Being shorter than the scapula of the same individual, and much shorter than the femur, the proportions of the humerus in the Iguanodon resemble more those of the extinct marine crocodile, called *Teleosaurus*, than those of any modern crocodile or lizard, and they indicate, as I have observed in a former Monograph, in connexion with the long, compressed, and vertically extended tail, the aquatic habits of this gigantic herbivorous reptile.

The head of the humerus, Pl. 19, fig. 4, *a*, is somewhat prominent, and projects inwards and backwards at right angles to the shaft, between two sub-equal tuberosities. From the external of these tuberosities, *b*, a deltoid ridge is continued nearly half way down the bone, and gives the greatest breadth to the shaft a little above its middle part, at *c*. Where it subsides, the shaft is bent a little inwards, becomes more rounded, contracts in diameter, and then gradually expands to the distal condyles, *d, d*. These are rounded and moderately prominent; the shaft above them offers a broad and shallow concavity anteriorly, fig. 5, and a moderately deep longitudinal depression behind, fig. 3, which is continued into that between them shown at fig. 6. In the length of the deltoid ridge the humerus of the Iguanodon approaches nearer to the form of that bone in the Crocodile than in the Iguana; but it resembles more the humerus of the Iguana in the degree of concavity of the fore part of the shaft above the condyles.

The radius and ulna, well shown in the Maidstone Iguanodon in the British Museum, and figured in Plates 1 and 2, '*Dinosauria*,' of the 'Section on Cretaceous Reptiles,' offer few differences worthy of notice, except their greater relative strength, from the corresponding bones in the Iguana. The olecranon of the ulna is more prominent and is rounded, as in the great monitor (*Varanus niloticus*).

Pelvis and Pelvic or Hinder Extremities.

The pelvis consists, as in recent reptiles, of the sacrum, with a pair of iliac, ischial, and pubic bones. The iliac bones, which would seem to become anchylosed to the sacrum in old individuals, have been already described, and are represented in Plates 8, 9, and 10, of the present Section, and in Plates 1 and 2, '*Dinosauria*,' of the 'Section on Cretaceous Reptiles.'

Pubis.—This bone, which presents a simple spatulate form in the Crocodile, already begins to increase in breadth at its symphysial extremity in the extinct family with concave vertebræ; and in the larger existing species of lizards is expanded at both extremities, and has a very marked and recognisable character superadded, in being bent outwards with a considerable curvature.

A massive fragment of a broad osseous plate, bearing a segment of a large articular cavity at its thickest margin, and thence extended as a thinner plate, bent with a bold curvature, and terminated by a thick rounded labrum, offers characters of the Lacertian type of the pubis too obvious to be mistaken. This specimen, now in the British Museum, (No. $\frac{187}{2187}$, Mantellian Catalogue), is from the Tilgate strata; and since the modifications of the ilium of the Iguanodon in the Maidstone skeleton approximate to the Lacertian type of the bone, and especially as manifested by the great *Varani* in which the recurved character of the pubic plate is most strongly marked, we may, with much probability, assign the fossil in question to the pelvis of the Iguanodon.

This fine portion of pubis is of an inequilateral triangular form, 16 inches in its longest diameter, 9 inches 6 lines across its base or broadest part, 6 inches 8 lines across its narrowest part. The fractured surface of the bone, near the acetabulum, is 3 inches 3 lines thick. The acetabular depression is 7 inches across, a proportion which corresponds well with the size of the cavity in which the head of the Iguanodon's femur must have been received. One angle of the cavity, corresponding with the anterior one in the *Varanus*, is raised; a broad and low obtuse ridge bounds the rest of the free margin of the cavity. The smooth labrum exchanges its character near one of the fractured edges of the bone for a rough surface, which indicates the commencement of the symphysis. In the apparent absence of the perforation below the acetabular depression, the present bone agrees with the crocodilian type.

Ischium.—A second fragment of a large lamelliform bone, also in the British Museum, (No. $\frac{188}{2188}$, Mantellian Catalogue), presents, in its general form and slightly twisted character, most resemblance to the ischium, with traceable modifications intermediate to those presented by the extinct *Goniopholis* and the modern *Varani* and *Iguanæ*. The loss of the acetabular extremity, which is broken away, prevents a certain determination of this bone; the only natural dimension that can be taken is the circumference of the neck, or contracted portion between the acetabular end and the expanded symphysial plate: this circumference gives 7 inches. The slight twist of the bone upon this part as it expands to form the broad symphysial plate,—a character which is well marked in the ischium of the *Goniopholis*,—gives it a superficial resemblance to the humerus of some large Mammalia; but the bone is too short in proportion to the breadth indicated by the fractured symphysial end, to afford any probability of its having been a humerus of a land reptile, and much less of the Iguanodon, in which the form of the humerus is now well ascertained.

Femur of the Iguanodon. Pl. 20, figs. 1, 1*a* and 1*b*. One fourth the nat. size.

Several specimens of this remarkable bone,—the one that most impresses the observer with the magnitude of the extinct reptile to which it belonged,—are preserved in the British Museum. Of these the most entire and perfect specimen, the subject of the above plate

references, measures nearly 3 feet in length; its circumference at the middle of the shaft is 18 inches; the contour of the rounded inward-projecting part of head, *a*, is $17\frac{1}{2}$ inches; two flat longitudinal facets meet near the middle of the anterior surface of the shaft at a rough and slightly elevated angle, *c*, which runs straight down to within thirteen inches of the distal end; the ridge there inclines towards the internal condyle and subsides. Two strong muscles, answering apparently to the *vastus internus* and *vastus externus*, are indicated by the surfaces converging to this ridge. The head of the bone is carried inwards, overhanging the shaft. The line of the inner side of the shaft describes a graceful sinuous curve, being first concave, then slightly convex at the middle, where there is a peculiar process or ridge sometimes called the "third trochanter," *d*, but which does not answer to the part so called, and projecting from the outer side of the femur, in the Rhinoceros and some other mammalia. The part answering to the great trochanter, *b*, is characterised by its compression in the direction of the bone from *a* to *b*, and its great breadth in the opposite direction: it is flattened externally and is divided by a deep and narrow fissure from the neck of the femur. The line of the outer side of the shaft is slightly concave as it descends from the great trochanter, is then convex along the middle part of the shaft, and is again concave as it is continued into the somewhat expanded external condyle, *e*. This condyle is narrow in the direction from *e* to *f*, fig. 1, especially at its prominent fore part, which has been broken off in the specimen figured: it gradually expands towards its back part, and the femur of the Iguanodon is characterised by the depth, as compared with the breadth, of the rotular, (fig. 1*b*, *r'*) and popliteal, fig. 1*b*, *p*, channels or cavities which separate the outer condyle from the inner one *f*. The inner border of the femur below the process *d* gradually inclines and expands to a flattened antero-posteriorly extended, slightly concave surface, which then descends vertically to the articular surface of the condyle, which surface extends horizontally at nearly a right angle with the line of the shaft of the bone. The antero-posterior extent of the flattened inner condyle is 8 inches. The thickness of the compact external wall of the shaft varies from half an inch to an inch and a half. The medullary cavity, at its widest part, has an area of four inches by two inches in diameter. Both ends of this fine bone are somewat crushed and mutilated.

The characters of the articular extremities of the femur which are obscured by the mutilated condition of the large specimen above described, are beautifully shown in the femur of a young Iguanodon, in the private collection of Mr. Holmes, obtained from a pit near Rusper, four miles north of Horsham. The rounded portion of the head extends inwards; it is indented at its anterior part by the commencement of a longitudinal broad channel, which extends down upon the shaft; the articular surface is not confined to the inwardly produced head, but extends over the whole proximal horizontal surface of the femur, expanding as it approaches the outer part of the head. The articular surface is circumscribed by a well-defined linear groove, which separates it from the longitudinal striated surface of the shaft of the bone. At the posterior and external angle of the articular

proximal end of the bone, a longitudinal column, the top of which may be compared to a trochanter, is separated by a deep and narrow vertical groove or fissure, from the main shaft of the bone, and falls into that shaf a little lower down: here the shaft expands and becomes rather flattened from before backwards, but is sub-quadrangular: a low ridge, produced by the union of two broad and flat surfaces, extends down the middle of the anterior surface of the shaft, and, inclining towards the inner condyle, gradually disappears. A little below the middle of the shaft the inner margin is produced into the angular ridge or low and long process, above described (*d*, fig. 1). The shaft of the bone has a large medullary cavity. The distal end is characterised by a deep and narrow anterior longitudinal groove, situated not quite in the middle, but nearer the external condyle; there is a corresponding deep longitudinal groove on the posterior part of the distal end, which is wider than the anterior one, and in the middle of the bone, separating the two condyles, but inclining beneath, and as it were undermining the backward projecting part of the internal condyle; this is much more prominent than the external one, which is traversed or divided by a narrow longitudinal fissure. The articular surface is irregular and tuberculate.

The following are some of the dimensions of this femur:

	In.	*Lin.*
The lateral diameter of proximal end	2	8
The lateral diameter of distal end	3	0
Antero-posterior diameter of outer part of proximal end . .	2	0
Antero-posterior diameter of outer part of internal condyle . .	2	3

In five separate long bones, in the Mantellian Collection, having the general characters of the two bones above described and of those of the Maidstone Iguanodon, which are marked "femur" in Pl. 2, '*Dinosauria,*' Section II, 'Cretaceous Reptiles,' Nos. 1 and 3 differ from Nos. 4 and 5 in the greater inward production of the head, making the concavity of the line descending from the head to the median internal ridge somewhat deeper. The lower angle of this median ridge is more produced in Nos. 1, 2 and 3, than in Nos. 4 and 5. The whole inner contour is more regularly concave in No. 5 than in Nos. 1 or 3. Of these five bones, No. 2 was found associated with a tibia and fibula; and the differences above indicated illustrate the extent of the individual varieties of the same bone, so far as my opportunities of comparison have extended.

The femur of the Iguana differs as widely from that of the Iguanodon as does that of the Monitor or any other Lacertian reptile. The forms of the head and trochanter of the femur of the Iguana are just the reverse of those in the Iguanodon. The head of the femur in the Iguana is flattened from side to side, and its upper convex surface is extended from before backwards, making no projection over the gentle concave line leading from its inner surface down to the inner condyle. In the Iguanodon the head is rounded and rather compressed from before backwards, and is produced, as in Mammals, over the inner side of the shaft.

In the Iguana the trochanter is compressed from before backwards, and is separated by a wide and shallow groove from the oppositely compressed head; in the Iguanodon the trochanter is singularly flattened from side to side, and is applied to the outer side of the thick neck, from which it is separated by a deep and narrow fissure. The Iguana has no sub-median internal process, and its distal condyles are slightly divided by a shallow depression.

The circumference of the femur of the Iguanodon very nearly equals one half its length; the circumference of the femur of the Iguana only equals one fourth its length; yet the femur of the Iguanodon equals the united length of eleven of its dorsal vertebræ, while that of the Iguana equals the united length of only six of its dorsal vertebræ.

The femora of the Iguana stand out, like those of most other Lacertians, at right angles with the vertical plane of the trunk, which is rather slung upon than supported by those bones; but it is evident from the superior relative length and strength of those bones in the Iguanodon, from the different conformation of the articular, especially the proximal extremities, and from the ridges and processes indicative of the powerful muscles inserted into the bone, that it must have sustained the weight of the body in a manner more nearly resembling that in the pachydermal Mammalia. As in some of the more bulky of these quadrupeds, the indication of the " ligamentum teres" is wanting in the head of the femur of the Iguanodon.

Tibia and Fibula of the Iguanodon. Pl. 20, figs. 2—7. One fourth the nat. size.

By the side of the femur, figured in Pl. 20, fig. 1, were found two other bones, the largest of which corresponds with the tibia in recent Crocodiles and Lizards. The homologous bone, better preserved, of a somewhat larger individual, is figured in Pl. 20, fig. 2. The external part of the head of this bone is produced horizontally, and its back part expands and divides into two condyles, *e*, *f*, fig. 2; the circumference of the proximal articular surface is 30 inches. The longitudinally finely striated vertical surface of the shaft of the tibia commences at the anterior part of the proximal end along a well defined curved line, which runs transversely across the bone, convex downwards in the middle, and concave downwards at each end: the bone gradually contracts, and assumes, about 8 inches below the head, the sub-quadrilateral form; it is broadest from side to side; its circumference is here 15 inches. The anterior surface is flattened; the outer side is convex or rounded; the dense external walls of this bone are very thick, at least 1 inch. The proximal articulation is convex from behind forwards, but, at the middle, it is slightly concave from side to side.

	In.	*Lin.*
Its lateral diameter is	12	0
Its antero-posterior diameter is	13	6

The fibula nearly equals the length of the tibia; the well-preserved specimen figured in Pl. 20, figs. 4—7, forms part of Mr. Holmes's choice collection of Wealden Remains from the vicinity of Horsham: it has belonged to a younger individual Iguanodon than the femur and tibia figured in the same plate.

The tibia of the Iguanodon equals the united length of nine of the dorsal vertebræ, while in the Iguana it does not exceed the united length of five dorsal vertebræ, although it more nearly equals the femur in length than in the Iguanodon. The head of the tibia is more expanded and more complicated by the condyloid prominences, and by their deep and wide groove in the Iguanodon than in the Iguana.

The disparity of strength between the tibia and fibula is considerable, but the difference in the thickness of the lower extremities of the two bones is less than the proportions of the shaft would indicate. On the middle of one of the flat sides of the fibula is an oblong rough surface slightly raised, measuring 3 inches by 2 inches. The articular extremities of the fibula are tuberculate, the lower and larger end is 5 inches across, the smaller one 3 inches across.

The fibula is more expanded towards the distal end and more flattened against the tibia in the Iguanodon than in the Iguana. It differs, also, from that of the Iguana in the well-marked, shallow, longitudinal concavity along the side of the lower half of the shaft which is next the tibia, as is shown in Pl. 20, fig. 4, (the views of the fibula in this plate have unfortunately been drawn on the stone upside down). The opposite side of the shaft is smooth and convex, as shown in fig. 3. In one diameter the fibula gradually contracts from the proximal to the distal end, as is shown in fig. 5; but in the opposite diameter it expands in a greater degree, and very suddenly, at the articular distal end. The form of the proximal surface is shown at fig. 7, that of the distal one at fig. 6.

The unusually perfect specimen, from which the figures 3-7 were taken, was obtained from the Wealden formation at the Tower-hill pit or quarry, near Horsham, by my esteemed friend G. B. Holmes, Esq., of that town, by whose accomplished daughter the original drawings of the bone were made. Another fibula of a small Iguanodon from a pit at Rusper, in the same gentleman's collection, equals the antero-posterior extent of the spines of eight dorsal vertebræ of the same individual. This bone is 13 inches long, 6 lines across the proximal end, and two inches across the distal end.

Metatarsal and Phalangeal Bones of the Iguanodon. Plates 21 and 22. Nat. size.

Of the great Iguanodon from the Horsham quarry, two metacarpal or metatarsal bones are preserved in natural juxtaposition, in Mr. Holmes's Museum: one exceeds the other by four inches in length, and measures 2 feet 6 inches: the breadth of its distal end is 3 inches 3 lines; the shaft is compressed and subtrihedral; its texture is

spongy at the centre. The proximal end is expanded, with a nearly flat articular surface, the contour of which is broken by two longitudinal indentations; the distal end offers a well-sculptured trochlear articulation for the first phalanx. The bone of the Maidstone Iguanodon (marked 'metatarsal' in the plate above cited) corresponds with the shorter of the two bones above cited.

Some of the phalanges, probably the middle ones, appear to have been singularly abbreviated; but they have not yet been discovered in such juxtaposition with undoubted Iguanodon's bones as to justify a more precise description of their characters under the present head.

Of the uppermost or proximal phalanges, one tolerably perfect specimen has long been known to palæontologists. It probably belonged to the left fore-foot of the Iguanodon, and is from the Wealden iron-sand which forms the shore of the Isle of Wight, east of Sandown Fort. This specimen, Pl. 21, fig. 1, is described by Dr. Buckland as a 'metacarpal bone' in the 'Geological Transactions,' vol. iii, 2d series, p. 425: it does not exhibit, however, any articular facet at the side of the proximal end for junction with a contiguous metacarpal; and at the distal end, instead of a uniform convexity, it presents the trochlear combination of a vertical convexity with a transverse concavity. The inference, therefore, as to the metacarpal bones of the Iguanodon being much shorter and thicker than in any living crocodiles or lizards, receives no support from the proportions of the present specimen.

The following is the notice of the original specimen, in the memoir above quoted.

"The first of these two new localities" (for fossil remains of the Iguanodon) "is on the south coast of the Isle of Wight, in the iron-sand which forms the shore, a little east of Sandown Fort, between high and low water. The most remarkable specimen I possess from thence is the gigantic metacarpal bone about to be described. The form of this bone nearly resembles one in the collection of Mr. Mantell, which Cuvier saw, and pronounced to be a metacarpal bone of the thumb of a reptile; but much exceeds it in size, measuring 6 inches in length, 5 inches in width at its largest diameter, and 16 inches in circumference at its posterior and largest extremity. Its weight is nearly six pounds.

"It is, I believe, the largest metacarpal bone which has been as yet discovered; and if we apply to the extinct animal from which it was derived, the scale by which the ancients measured Hercules ("*ex pede Herculem*"), we must conclude that the individual of whose body it formed a part, was the most gigantic of all quadrupeds that have ever trod upon the surface of our planet. The corresponding bone in the foot of the largest elephant is less than our fossil metacarpal by more than one half. The bone represented by Mr. Mantell (Pl. 14, figs. 4, 5, of his 'Fossils of Tilgate Forest') approaches the nearest of all those engraved by him in this work, to our bone from Sandown Bay. He considers his fossil to be most probably a metatarsal bone of the Iguanodon, and states that he has one such bone which measures $4\frac{1}{2}$ inches in

length, and 13 inches in circumference at the largest tarsal extremity. The colossal proportions of a fragment of a femur in his possession, from Tilgate Forest (Pl. 18, fig. 1 of the same work), which measures 23 inches in circumference in the smallest part, sufficiently accord with those of his metatarsal bone last mentioned, as well as our metacarpal bone from the same formation in the Isle of Wight, and give strong probability to the opinion that all these three fragments of the skeleton of a reptile of such extraordinary stature may be referred to the Iguanodon. It is obvious that these supposed metacarpal and metatarsal bones are much shorter and thicker in their proportions than the metacarpal or metatarsal bones of any living lizards or crocodiles; but when we consider the enormous weight which the foot of an animal whose femur was 23 inches in circumference must have sustained, a reduction of length and increase of bulk in the bones which supported such a colossal frame, must have been attended with many mechanical advantages."

The distal or ungual phalanges of the Iguanodon, although doubtless offering certain modifications of form in different toes, are shown by those preserved in the Maidstone Iguanodon, and by others of much larger dimensions found associated with the bones of the great Iguanodon of the Horsham quarry, to have had a less incurved, broader, and more depressed form than in other known saurians. Two of the largest ungual phalanges of the Horsham Iguanodon in Mr. Holmes's collection, are broad, subdepressed, and exhibit, as in most other saurians, the curved vascular groove on each side: they have an articular, slightly concave base, and terminate anteriorly in a round blunt edge; the outer boundary of the lateral grooves form at the posterior end of the groove, a laterally projecting process, making this part of the phalanx broader than the articular extremity or basis. The following are dimensions of the largest of the two phalanges:

	In.	*Lines.*
Length	5	4
Breadth	3	2
Breadth at articular end	3	0
Depth	2	3

at the posterior end it gradually diminishes to the distal end.

The phalanx is slightly bent downwards; the under surface being concave longitudinally, but convex from side to side. The under surface is rough, the upper surface nearly smooth, except at the margin of the articular surface, on the projecting sides and at the distal extremity, which is sculptured by irregular vascular grooves and holes. The phalanx has a slight oblique twist to one side, and is somewhat thinned off to that side on which the curved groove is longer than on the other side.

In Mr. Saull's museum is an ungual phalanx of an Iguanodon, which nearly equals those from Horsham, and presents the same subdepressed form. The base is slightly convex transversely, more concave vertically; the articular surface is

faintly divided by a median vertical rising; the rounded edge of the articular surface is slightly raised, and is interrupted on both sides by smooth shallow commencement of the curved vascular groove; this deepens and contracts as it extends forwards. The upper surface of the phalanx is convex longitudinally and transversely; the lower surface is rather more convex transversely than the upper, but is slightly concave longitudinally. The upper and lateral surfaces, for about an inch near the base, are deeply sculptured by large irregular longitudinal grooves and ridges; the rest of the upper surface is impressed by fine interrupted longitudinal impressions, but having, on the whole, a smooth appearance. The laminated superposition of the exterior compact portion of the bone is shown by the separation of portions of the layers of about one line in thickness. The under surface is more deeply impressed by cavities having reticulate elevations. The right aliform process begins 10 lines from the articular surface, the left about 14 lines from the same part; this base is bounded below by slight impressions, and above by the lateral canals, which appear to sink into the bone. A few distant vascular grooves mark the upper surface of the bone, but more numerous larger ones are situated near the lateral canals and at the broken anterior end of the phalanx. The following are its dimensions:

	In.	*Lines.*
Transverse diameter of bone	3	5
Transverse diameter of broken end	2	2
Vertical diameter of base	2	7
Vertical diameter of broken end	1	6
Length to broken end	4	4

The largest phalanx of this kind which has hitherto come under my observation is one (Pl. 21, fig. 2) which had been washed out of the same tidally submerged Wealden iron-sandstone, which forms the shore between high and low water to the east of Sandown Fort, Isle of Wight. This phalanx had been rolled and waterworn, like most of the saurian fossils from that locality. The margins of the articular base of the phalanx are thus rounded off, and those of the sides and extremity have been worn away, rendering the latter more obtuse. Nevertheless, in this state, the phalanx measures 6 inches in length and $4\frac{1}{4}$ inches in breadth, much surpassing in size the largest ungual phalanx of the elephant, mammoth, or mastodon. It would be unsafe, however, to infer from the size of a claw or the bone supporting it that of the entire animal; an ungual phalanx presents very different proportions to the rest of the limb and to the entire animal, in different species: that of a horse, *e.g.*, exceeds in size that of an elephant: and the ungual phalanx of a sloth is longer than that of the largest crocodile. In the general proportions, and broad subdepressed form of the bone here described, it resembles the more perfectly preserved ungual phalanges known by their association with other parts of the skeleton to have

belonged to the Iguanodon. The outer boundary of each lateral vascular groove expands to form similar aliform projections, as at *b*, fig. 2; the grooves terminate rather abruptly, but do not penetrate the substance of the bone. The upper surface, between the lateral grooves, is convex and smooth; the under surface, shown in the figure, is rough, and impressed by irregular vascular grooves and foramina. In its size and proportions this phalanx agrees with the proximal one figured in the same plate, (Pl. 21, fig. 1); it may have belonged to the same individual, and certainly came from an Iguanodon of the same colossal proportions.

Among the few other phalangeal bones from Dr. Mantell's collection in the British Museum, there is one (figured in the 'Wonders of Geology,' pl. iii, fig. 1, as belonging to the fore-foot of the Iguanodon) which differs in a marked manner from the specimens just described, being as much compressed from side to side as some of the unquestionably Iguanodon's ungual phalanges are flattened from above downwards. One of these compressed phalanges must have been at least 4 inches in length; it now measures 3 inches, with the extremity broken off; it is 2 inches 8 lines in vertical diameter at the base, and only 1 inch 2 lines in the greatest transverse diameter. The phalanx is more curved downwards than any of the true Iguanodon's phalanges, and is traversed by a longer and shallower groove, the lower margin of which is not produced into a lateral aliform process, nor does the distal end of the groove sink into the substance of the bone. The ungual phalanges on both the fore and hind feet of the Iguana resemble this phalanx in form more than they do those of the Iguanodon. In the fore-foot of the crocodile the ungual phalanx of the first or innermost toe is broad and flat, with lateral ridges, much resembling the depressed phalanges of the Iguanodon. The ungual phalanx of the third digit is of the same length, but is thinner in both transverse and vertical directions, though less so in the latter; it is not more curved. Still the difference, and this is the greatest that I can perceive in comparing the different ungual phalanges of the same individual crocodile (*Croc. acutus*), is much less than that which is manifested between the depressed and the compressed phalanges hitherto referred to the Iguanodon. It is highly probable that the terminal phalanges of the different toes of the Iguanodon were somewhat varied in form; but the compressed incurved phalanx supposed to characterise the fore-foot of that great herbivorous reptile, appears to me to present rather the form of the phalanx of a great carnivorous Saurian. In the great proportion of the skeleton found near Maidstone are two phalanges which correspond in form with those enormous specimens found near Horsham, and on the south coast of the Isle of Wight, and with the small depressed claw-bones from Tilgate Forest, unquestionably belonging to the Iguanodon, and supposed by Dr. Mantell to be peculiar to the hind foot of that Saurian.

Amongst the varieties of large fossil ungual phalanges discovered in the Wealden of Kent, Sussex, and the Isle of Wight, I should be more disposed to refer to a herbivorous Saurian that modification which is less incurved than the typical form in

the Iguanodon, and which exhibits that straighter and more conical form of phalanx, Pl. 22, figs. 1, 2, 3, (No. $\frac{384}{2384}$ "Horn of the Iguanodon" Mantellian Collection and Catalogue) described in p. 141 of my 'Report on British Fossil Reptiles,'* and the determination of which, as a phalanx, in that 'Report,' subsequent acquisitions of similarly modified phalanges, *e. g.*, figs. 4, 5, Pl. 22, have served to confirm.

As, however, the original opinion of the indefatigable explorer of the Wealden, to whom we owe our chief knowledge of that formation in England, has continued to prevail in the numerous geological and palæontological works published since 1841, it is incumbent on me to enter more into detail relative to the fossil on the nature of which I found myself, at an early period of these researches, compelled to differ with its discoverer.

A certain resemblance in outward form, which the fossil teeth of the Iguanodon present to those of the Iguana, has exercised, as I have already intimated, undue influence in the prevalent ideas as to the affinities of the gigantic herbivorous reptile of the Wealden to the small existing lizard, after which it has been named. The Iguanodon, indeed, is generally supposed to have been characterised by a singular structure, viz., a horn, like that which, in the existing order of Saurians, distinguishes one of the species of Iguana, (*Metopoceros*, or *Iguana cornuta*).

The following observations on the fossil which has given rise to that opinion, may tend in some degree to modify, and I believe to rectify the received ideas as to the nature and affinities of the Iguanodon.

The bone to which I allude is that which Dr. Mantell has described as the "horn of the Iguanodon" in the following words, which convey an accurate idea of its general form and size.

"We have," says Dr. Mantell, "to request the reader's attention to a very remarkable appendage with which there is every reason to believe the Iguanodon was provided. This is no less than a *horn,* equal in size, and not very different in form, to the upper horn of the rhinoceros. This unique relic is represented of the natural size, Pl. XX, fig. 8.† It is externally of a dark brown colour, and while some parts of its surface are smooth others are rugous and furrowed, as if by the passage of blood-vessels. Its base is of an irregular form, and slightly concave. It possesses an osseous structure, and appears to have no internal cavity. It is evident that it was not united to the skull by a bony union, as are the horns of the mammalia."

The only reason which I have, hitherto, been able to find adduced for the above determination of the fossil described as "the horn of the Iguanodon," is, that a species of Iguana has, on the middle of its forehead, an osseous conical horn or process covered by a single scale."‡

* 'Reports of the British Association,' 1841.

† 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 78, pl. xx, fig. 8.

‡ Loc. cit., cited from 'Shaw's Zoology.'

The first and most obvious objection to the fossil in question, (No. $\frac{384}{2384}$, Mantellian Collection, British Museum), being the bony core of a median frontal horn, is its *want of symmetry*. This is plainly manifest in two respects; first, by the obliquity of the base; and secondly, hold it as you may, by the inequality and difference of form of the two sides. If the fossil be viewed with the apex upwards and forwards, as in the position in which Mr. Dinkel has delineated it, Pl. 22, fig. 1, when I desired him to draw it in the position in which it appeared least unsymmetrical, even then the left side is, by reason of the basal obliquity, longer than the right, and it is more convex in the vertical direction. This view exposes what I believe to be the left side of the phalanx.

With respect to the base of the bone, all its natural surface, with the exception of one small spot, has been chiselled or scraped away, and the central coarse cellular structure of the bone is thus exposed. That single smooth spot, however, indicates that the base had been articulated by a synovial joint, and the form of the rest of the mutilated basal surface nowise militates against the supposition of the conical bone having been *the terminal unsymmetrical ungual phalanx* of the outer toe of a great Saurian reptile.

The want of symmetry in the ungual phalanges of the outer and inner digits of a reptile's foot, in which phalanges one side becomes longer and more convex than the other, exemplifies the nature of that degree of want of symmetry which exists in the fossil in question, and which ought of itself to be decisive against the opinion of such fossil being the basis of a single median frontal horn.

Yet this idea has been so long fixed and is so generally received, that, although the objection above advanced may unsettle it, yet additional reasons may be expected before it will be finally abandoned. For, to the objection of mere want of symmetry, it may be replied, that this particular example of the horn of the Iguanodon may exhibit an accidental deviation from the normal structure; although, indeed, an unsymmetrical horn has never been noticed in the horned Iguana (*Metopoceros*). Yet even at this stage of the argument it will not be hard to decide between *a phalanx* to which the unsymmetrical form presented by the fossil is natural, and *a horn* in which such dissymmetry would be monstrous. Independently, however, of general configuration there are other characters by which an unequal phalanx of a crocodilian or other large Saurian may be detected.

An ungual phalanx is a significant bone; it has relations which no other phalangeal or other bone of a foot possesses, and has modifications of surface, of form, and structure subservient to those relations.

First, it supports the strong horny sheath or claw which immediately presses upon the ground, and which accordingly needs constant and copious reparation. An ungual phalanx, therefore, besides its own "periosteum" is invested by a highly vascular and almost glandular "corium," which is the active renovator of the worn-down claw.

All ungual phalanges of Saurian reptiles are marked on each side by a large, more or less deep and smooth groove, curved with the convexity towards the upper side of the claw. These grooves convey the blood-vessels and nerves to the matrix of the claw, and, in some species, sink at their distal end into the substance of the claw-bone.

But, it may be said, the bony basis or core of a frontal horn likewise supports a corneous sheath, and is invested by the vascular cutis which secretes that sheath. Since, however, the corneous sheath of a horn, and especially of so small a one as that which arms the head of the *Iguana cornuta,* and, as has been imagined, also of the Iguanodon, is less constantly and rapidly abraded than a claw, so the indications of the vascularity and activity of the reproductive organ are much more feebly marked upon the horn-core than upon the phalanx. They are also marked in a different manner. The horn-core is incased by its horny sheath, its base alone being free from that covering. The renovation of the horn takes place, as is well known, chiefly at the base, and the numerous vascular impressions are distributed pretty equally round the base of the core.

In the Saurian claw-bone the upper surface and sides are invested by the claw, and the renovation of the corneous matter is required near the sides of the distal half of the osseous cone. Hence in the phalanges of the large Saurian we see the large vascular curved groove extending along each side, and the canals by which the vessels and nerves emerged from the bone upon its immediately investing vascular organ of the claw are most conspicuous on each side near the apex.

Now the fossil in question exhibits conspicuously the two lateral, curved, wide and deep vascular grooves, *c*, *c'*, *d*, *d'*, figs. 1 and 2, Pl. 22; and each groove sinks at its distal end, *c*,' *d'*, into the substance of the bone; the large oblique foramina, *e*, by which the blood-vessels and nerves emerged to supply the secreting organ of the claw are also present in greatest number on each side of the apex of the bone: these characters I hold to be decisive of the phalangeal nature of the so-called horn.

The groove on the right side of the phalanx, (fig. 2, *c*) as seen in a view of its upper surface, which is determined by the convexity of the vascular grooves, is entire: it begins about two thirds of an inch from the base, is shallow at first, but gradually becomes deeper, until it sinks into the substance of the bone (at *c'*): it presents the usual gentle and regular curve, convex upwards; its length, following the curve, is $1\frac{1}{2}$ inch; it sinks into the osseous substance nearly two inches from the broken apex of the phalanx; its breadth is between 2 and 3 lines.

On the left side, fig. 1, a portion of the vascular groove, *d*, *d'*, is obliterated by the loss of part of the compact outer layer of the upper surface of the phalanx, forming the median edge of the groove, but the lateral or outer, and the terminal half inch of the groove where it sinks into the substance of the bone, as at *d'*, figs. 1 and 2, is entire: enough remains, therefore, to show that the groove on the left side of the phalanx had

the same degree and direction of curvature as that on the right side; but the left groove becomes shallower and wider towards its beginning, which may be traced as far back as the base of the phalanx, as in Mr. Saull's specimen. The vascular foramina, at and beyond the opposite termination of the left groove, are not less numerous and conspicuous than are those on the right side; but the left groove is somewhat in advance of the right, and sinks into the unsymmetrical phalanx one inch and four lines from the broken apex. At one fourth of an inch below the left vascular groove there is a shallow, smooth impression, *f*, fig. 1, along the distal half of the bone, indicating the extent to which the lateral margin of the claw reached on that side: there is no corresponding impression on the opposite side, which coincides with the dissymmetry of the phalanx, in showing it to have belonged either to an outermost toe of the left foot, or to an innermost toe of the right foot.

The exterior of the bone around its base is sculptured, as in other and normally shaped phalanges, by smaller but coarse longitudinal impressions, corresponding with the attachments and insertions of the articular capsule and ligaments. The part of the bone, proved by the direction of the large smooth lateral grooves to be the under side, is the shortest, and is most convex transversely. The upper side is the longest, and is narrower across than the under side.

	In.	*Lines.*	
The length of this phalanx is . . .	4	6	(doubtless 5 in. when entire.)
The longest diameter of its base is . .	3	3	
The shortest diameter of its base is . .	2	2	
The distance between the distal terminations of the lateral grooves	1	0*	

It must be remembered that no skull of the Iguanodon has yet been found. What might be the chances, it may be asked, that the single small bone supporting the median frontal horn should be found fossil, on the hypothesis that the Iguanodon possessed, like the *Iguana cornuta*, such a dermal appendage? Supposing an extreme toe, outermost, or innermost, of the fore and hind feet of the great reptile to have had a claw shorter and straighter than the rest, it would be four to one that the bone of such claw should be found, than the unique bone of the horn. By great good luck, indeed, the latter might once turn up; but one could not expect the only bone of its kind, and one of the smallest in the skeleton of the Iguanodon, to be frequently found. Yet I have had not less than three "horns of the Iguanodon" submitted to my inspection since describing the one so called in the British Museum. And two of these supplemental examples of straight conical claw-phalanges are figured in Pl. 22. The first, figs. 3 and 4, was discovered in the Wealden of the Isle of

* The two figures in Pl. 22 have been made with the most scrupulous accuracy from the original fossil now in the British Museum, and exhibit characters not before given in any published figure of the so-called "horn of the Iguanodon."

Wight, and is in the collection of Felix Knyvett, Esq., by whose kind permission it is here described and figured. It has an irregular, slightly concave base, broader than it is high, and has a well-marked deep vascular groove on each side: that to the left, *d'*, skins into the substance of the bone as it approaches the apex, where it communicates with several large vascular foramina: the right groove, *e*, resembles that in fig. 2, in being shorter and more curved; but it seems to have given off its branches to the claw-forming matrix before sinking into the substance of the bone: the upper surface between these grooves is narrower and less convex than the under one, in which respect this phalanx also resembles figs. 1 and 2. Fig. 3 gives a side view, the left, of the second example of straight conical phalanx, showing the narrowest transverse diameter of the bone, as in fig. 1. Fig. 5 is a smaller phalanx of the same unsymmetrical, conical form, with an irregular slightly concave basal articulation, and with impressions of the two lateral vascular grooves; that on the left side, *d'*, being the best marked, and sinking into the substance of the bone, as in the other specimens figured. It is from the Wealden of Battle, Sussex; and is also in the collection of Felix Knyvett, Esq.

Having thus, as I believe, determined the true nature of the supposed horn of the Iguanodon, and lowered the problematical fossil from its place on the forehead to the end of one of the toes of some great Wealden Saurian, it remains to inquire to which of the gigantic reptiles of that formation the present phalanx may be, with most probability, referred.

There are three forms of fossil phalanges from the Wealden strata. One is broad, depressed, subsymmetrical, rounded at the apex, with the outer boundary of each lateral vascular groove produced like two aliform ridges, and the grooves commonly terminating without sinking into the bone.

This form of phalanx Dr. Mantell to refers the hind foot of the Iguanodon: and that it belongs to the Iguanodon is shown by the instructive series of bones of the same individual, rescued by Mr. Bensted from the Green Sand quarry at Maidstone.

Another form of phalanx is the reverse of the above, being compressed, curved downwards, with the lateral grooves longer and shallower, and their lower or outer boundary is not produced into an aliform process. This form is figured in the 'Wonders of Geology,' pl. iii, fig. 1, as belonging to the fore foot of the Iguanodon.

The ungual phalanges on both the fore and hind feet of the Iguana resemble this second form more than they do the first; but by no means differ from each other, as those of the Iguanodon must have done on Dr. Mantell's hypothesis.

In the fore foot of the Crocodile the ungual phalanx of the first toe is broad and depressed, with lateral ridges, and more resembles the phalanx in the Maidstone Iguanodon: the ungual phalanx of the third digit of the Crocodile is of the same length as the first, but is thinner in both transverse and vertical directions, though least in

Considering the great numbers of teeth and bones of the Iguanodon that have been

the latter: it is not more curved than the first. Still the difference, which is the greatest I can detect in comparing the different ungual phalanges of the same Crocodile, is much less than that which is manifested by the depressed and compressed phalanges hitherto deemed to characterise the hind and fore feet of the Iguanodon. I think it more probable, therefore, that the second form of Wealden phalanx appertains to a distinct species from the Iguanodon, and probably to a carnivorous Saurian.

The third form is that which, less depressed than the first and less curved than the second, has been described as *the horn* of the Iguanodon. The outer border of the lateral vascular grooves are very slightly produced, and the grooves themselves commonly sink into the substance of the bone, as they do in the great phalanges of the Cetiosaurus. Some of these straight conical phalanges, *e. g.*, those figured in Pl. 22, figs. 1, 2, 3, and 4, seem to be too large for the *Hylæosaurus*.

But I shall refrain, at present, from indulging in conjecture, however probable, as to the species of reptile to which this third form of phalanx belongs, satisfied with the present evidence of the nature of the bone itself, and that, if it ever formed part of the skeleton of the Iguanodon, it belonged to the foot and not to the head: and I shall conclude by briefly summing up the characters which ought to be borne in mind when the idea of the little modern Iguana is associated, through similarity of sound, with that of the great Iguanodon.

Both articular ends of the vertebræ of the Iguanodon are nearly flat, thereby differing more from the concavo-convex vertebræ of the Iguana than those of any existing Crocodile or Lizard do.

The anterior ribs of the Iguanodon have a head, neck, and tubercle, and a double articulation with the cervical and dorsal vertebræ; those of the Iguana and of every other existing Lizard have no cervix or tubercle, and have only a single articulation with the cervical and dorsal vertebræ. In this important modification of the anterior ribs the Crocodile has a greater resemblance and closer affinity to the Iguanodon than the Iguana has.

The height, breadth, and outward sculpturing of the neural arch of the dorsal vertebræ of the Iguanodon, are characters wanting in the Iguana and all modern Lizards, but are remotely approximated to in the dorsal vertebræ of the Crocodile, which, however, are far from presenting the expansion and complexity of the dorsal neural arches in the Iguanodon.

Five vertebræ of unusual construction are anchylosed together to form the extended sacrum of the Iguanodon: in the Iguana the small and simple sacrum consists of only two slightly modified vertebræ; in this respect it more closely resembles other Lizards, and even the Crocodiles, than it does the Iguanodon.

The important difference in the structure of the teeth of the Iguanodon and Iguana, is pointed out in the Section on 'Cretaceous Reptiles,' pp. 269—271.

Integument of the Iguanodon. Pl. 20, fig. 8.

In that part of the specimen of the skeleton of the young Iguanodon, figured in Pl. 6, which is in the Museum of Mr. Bowerbank, some portions of a layer of dark, finely granulated carbonaceous matter, were found imbedded between the ribs, near the middle of the side of the trunk, and slightly adhering to the discoloured matrix: this layer is very probably, as Mr. Bowerbank believes, a part of the integument of the Iguanodon. Of the best preserved portions of this substance, the largest is an oblong one, 8 lines in long diameter; another is 6 lines in diameter; and both are about 1 line in thickness. Supposing the Iguanodon to have been covered by epidermal scales like those of the Iguana, and of proportional size, a single scale would cover from four to six times the extent of corium which is shown by the largest of the above specimens, on the supposition that they are parts of the true skin of the Iguanodon.

The firmer and more enduring parts of the substance here displayed seem to have consisted of coarse fibres, irregularly interlacing each other; these form the darker parts which rise above the surface and give it, when viewed by the naked eye, a subgranular character; the depressions indicate the interspaces of the fibres, and contain fine particles of a substance of a lighter colour. I have not been able to detect any clear traces of ultimate organic structure in the black carbonized remains of the fibrous tissue.

So much of structure as is discernible accords well with that of the corium of a tough and thick skin; but no conclusions can be satisfactorily deduced from the small portions here preserved, as to the nature of the defensive covering, epidermal or osseous, of the corium of the Iguanodon. The experienced microscopist to whom I am indebted for the opportunity of inspecting these rare and interesting specimens, writes to me: "I have examined the skin with the greatest care with my microscope, but I cannot find any indications of scales." My own observations have led to the same result. The visible character, however, of the surface of the supposed fossil skin of the Iguanodon, is not inconsistent with that of the vascular corium of a reptile which nourishes an overlying epidermal scale, or osseous plate or scute, either of which parts, if present in the living animal, would be most probably much larger than the largest of the fragments that have been here preserved. The chief difference between the corium of a squamate and that of a loricate reptile, is its less thickness in the latter where it underlies bone, than where it supports a scale, as in the squamate species.

Allowing for the extreme shrinking and condensation of skin which has become carbonized in the present rare instance, and has resisted the common result of the dissolving agencies, I should infer from these fragments that they might have originally been of that thickness which is consistent with an external covering of epidermal material.

collected from different localities during the last thirty years, and the collocation of some of these remains so as to prove that the entire carcase of an Iguanodon had been imbedded in the matrix, as in the case of Mr. Bensted's discovery near Maidstone, fossil bony scutes, had they existed in any quantity in the skin of the Iguanodon, might reasonably be expected to have been found associated with the parts of the endo-skeleton. Such dermal bones have been discovered in connection with other remains of the *Hylæosaurus*, and we may, therefore, with more confidence assign its value to the negative evidence in the case of the Iguanodon, and conclude that the surface of its nuge body was defended by thickened epidermis, either coextensive with the chorion, or specially developed and multiplied in the form of scales.

Size of the Iguanodon.

From the comparison, which the few connected portions of the skeleton of the Iguanodon enable us to make, between the bones of the extremities and the vertebral column, it is evident that the hind legs at least, and probably also the fore legs, were longer and stronger in proportion to the trunk than in any existing Saurian. One can scarcely suppress a feeling of surprise that this striking characteristic of the Iguanodon, in common with other Dinosauria, should have been so long overlooked; since the required evidence, as pointed out in my 'Report on British Fossil Reptiles,'* is only an associated vertebra and long bone of the same individual, or a comparison of the largest detached vertebræ with the longest femora or humeri. This characteristic is, nevertheless, one of the most important towards a restoration of the extinct reptile, since an approximation to a true conception of the size of the entire animal could only be made after the general proportions of the body to the extremities had been ascertained.

It was obvious that the exaggerated resemblances of the Iguanodon to the Iguana misled the Palæontologists who had previously published the results of their calculations of the size of the Iguanodon;† and, hence, the dimensions of 100 feet in length arrived at by a comparison of the teeth and clavicle of the Iguanodon with the Iguana, of 75 feet from a similar comparison of their femora, and of 80 feet from that of the claw-bone; which, if founded upon the largest specimen from Horsham, instead of the one compared by Dr. Mantell, would yield a result of upwards of 200 feet for the total length of the Iguanodon, since the Horsham phalanx exceeds the size of the largest of the recent Iguana's phalanges by 40 times!

But the same reasons which I have assigned for calculating the bulk of the Megalosaurus on the basis of the vertebræ,‡ apply with equal force to the Iguanodon.

* Reports of the Brit. Association, 1841, p. 142.

† Mantell, 'Geology of the South-east of England,' p. 314. Buckland 'Bridgewater Treatise,' p. 243.

‡ Reports of the Brit. Association, 1841, p. 109.

Now the largest vertebra of an Iguanodon which has yet been obtained does not, as has been before stated, exceed $4\frac{1}{2}$ inches in length; the most common size being 4 inches. The intervertebral substance is shown, by the naturally juxtaposed series of dorsal vertebræ in the Maidstone Iguanodon, to be not more than one third of an inch in thickness. All the accurately determined vertebræ of the Iguanodon manifest the same constancy of their antero-posterior diameter which prevails in Saurians generally; the discovery of the true character of the supposed Lacertian vertebræ, six inches in length, removes the only remaining doubt that could have attached itself to this important element in the present calculation.* The anterior cervical vertebræ of the Iguanodon, when discovered, if they prove to differ in length from the known dorsal and caudal vertebræ, will be, in all probability, somewhat shorter, as they are in the Hylæosaur and in all known Crocodiles and Lizards. It remains, therefore, to determine the most probable number of the vertebræ of the Iguanodon, in order to apply their length individually to the estimate of the length of the entire body. The structure of the vertebræ and the ribs, and especially the variation in both structure and size which the ribs of the Iguanodon, already obtained, demonstrate to have prevailed in the costal series, render it much more probable that the number of the costal vertebræ would resemble that of the Crocodiles than that of the *Scincus* or other Lizards with unusually numerous dorsal vertebræ, and which possess ribs of a simple and uniform structure, and of nearly equal size. The most probable number of vertebræ of the trunk, from the atlas to the last lumbar inclusive, calculated from Crocodilian analogies, would be 24 vertebræ. This is the number indicated by the instructive portion of the skeleton of the young Iguanodon figured in Pl. 6, and for the first time described in the present Section: it is also the number possessed by the Iguana.

Twenty-four vertebræ, estimated with their intervertebral spaces at 5 inches each, give 10 feet; if to this we add the length of the sacrum, viz., 17 inches, then that of the trunk of the Iguanodon would be 11 feet 5 inches; which is about equal to that of the Megatherium. If there be any part of the skeleton of the Iguana which may with greater probability than the rest be supposed to have the proportions of the corresponding part of the Iguanodon, it is the lower jaw, by virtue of the analogy of the teeth and the substances they are adapted to prepare for digestion. Now the lower jaw gives the length of the head in the Iguana, and this equals the length of six dorsal vertebræ, so that as 5 inches rather exceeds the length of the largest Iguanodon's vertebra yet obtained, with the intervertebral space superadded, on this calculation the length of the head of the largest Iguanodon must have been about 2 feet 6 inches, and this is nearly the length of the head, as estimated on the data afforded by the portions of lower jaw described at pp. 20—30. In the description of the caudal vertebræ it has been shown that the Iguanodon could as little have

* Reports of Brit. Association, 1841, p. 92.

resembled the Iguana in the length of its tail,* as in the anatomical characters of any of the constituent vertebræ of that part: the changes which the series of six caudal vertebræ present in the length and form of the spinous processes, and in the place of origin of the transverse processes, indicate the tail to have been relatively shorter in the Iguanodon than in the Crocodile. Assuming, however, that the number of caudal vertebræ of the Iguanodon equalled that in the Crocodile, and allowing to each vertebra with its intervertebral space $4\frac{1}{2}$ inches, we obtain the length of 12 feet 6 inches for the tail of the Iguanodon. On the foregoing data, therefore, we may liberally assign the following dimensions to the largest Iguanodon:

	Feet.
Length of head, say . . .	3
Length of trunk with sacrum . .	12
Length of tail	13
Total length of the Iguanodon .	28

The same observations on the general form and proportions of the animal, and its approximation in this respect to the Mammalia, especially the great extinct Megatherioid or Pachydermal species, apply as well to the Iguanodon as to the Megalosaurus.

* See also the judicious remarks by Dr. Buckland to the same effect, 'Bridgewater Treatise,' p. 244.

ORDER—*DINOSAURIA*.

Genus—MEGALOSAURUS,* *Buckland*.

Dentes laniarii, subcompressi, marginibus minuté serratis.

THE order or group of Dinosaurian Reptiles, briefly characterised in the preceding division of the present chapter,† includes at least three well-established genera, resembling each other in having a large and complex sacrum, composed of five or more anchylosed vertebræ; in the height, breadth, and outward sculpturing of the neural arch of the dorsal vertebræ; in the twofold articulation of the ribs, or some of the anterior moveable ribs, to the vertebræ; and in having broad, and sometimes complex coracoids, and long and slender clavicles; whereby a Lacertian type of the pectoral arch is combined with a crocodilian type of the true vertebræ, and both with an ornithic type of sacrum.

These remarkable extinct Dinosaurs were of large, if not gigantic, size; with the trunk lifted, higher than in other reptiles, upon four unusually developed limbs; the principal bones of which are remarkable for the prominence and number of the apophyses relating to muscular attachments, for the size of the medullary cavity, and for the density of its compact bony wall: the limbs are terminated by metacarpal or metatarsal, and by phalangeal bones, which, with the exception of the ungual phalanges, more or less resemble those of the horny pachydermal mammals, and attest, with the hollow long bones, the terrestrial habits of the species.

Of these gigantic *Dinosauria* the most formidable was that which its discoverer, that keen observer and original thinker, the Rev. Dr. Buckland, has called "Megalosaurus,‡" in reference to the idea of its hugeness, which was suggested to both him and Baron Cuvier by certain of its limb-bones. "Si l'on pouvait donner," writes Cuvier, "le nom de *Lacerta gigantea* à un autre animal qu'à celui de Maëstricht, c'est l'espèce actuelle qui le mériterait; son seul fémur, long de trente-deux pouces anglais ou 0·805; annoncerait, en lui supposant les proportions d'un Monitor, une longueur totale de plus de quarante-cinq pieds de roi, et même, s'il y a de ces fémurs de quatre pieds et plus, comme on l'a dit, sa longueur serait encore plus étonnante."§

* Μεγας, great, σαῦρος, lizard.

† Page 275.

‡ See 'Transactions of the Geological Society of London,' 4to, vol. i, 2d ser., pt. 2, 1824.

§ 'Ossemens Fossiles,' 4to, vol. v, pt. 2, p. 343.

The locality where the first rightly recognised remains of the *Megalosaurus* were found was Stonesfield, near Woodstock, about twelve miles from Oxford. The formation is that calcareous schist, which, being quarried for roofing houses principally at Stonesfield, is called, in most English geological works, "Stonesfield slate." Its position is at the base of the great Middle Oolitic series, where it may be, perhaps, more accurately classed as an upper member of the Inferior Oolite.

To get at this slate, pits are sunk through forty-feet or more of superincumbent strata, chiefly consisting of that hard oolitic rock called "cornbrash" by the quarry-men. The schistose or slaty deposit is not more than six feet thick; and the scepticism with which the first announcement of bones of large animals in stony strata at that depth was received, is exemplified by the stress with which Cuvier thought it needful to insist on the fact that the Stonesfield slate was as regular a formation as it was an ancient one, and that there was no ground for supposing that the fossil bones which it contained had penetrated it by any fissure or other accidental opening.

The portions of skeleton originally discovered, and attributed by Dr. Buckland to his newly defined genus, *Megalosaurus*, consisted of a fragment of the lower jaw, a femur, a series of five vertebræ of the trunk, a few ribs, a coracoid bone, a clavicle, and some less certainly recognisable fragments.*

Unfortunately, as Cuvier has remarked, those portions were not found together in one spot, nor, with the exception of the five vertebræ, were the bones associated two to two, or three to three, so as to make it probable that they belonged to the same individual; and, with regard to their zoological or anatomical relations, Cuvier further observes that these are of a somewhat equivocal and mixed nature, "encore ces rapports zoologiques sont-ils d'une nature assez equivoque et assez mélangée."†

This side-blow to Dr. Buckland's determination has been repeated by later foreign palæontologists. M. Deslongchamps, for example, has remarked, "Qu'il n'y a de bien décidément constaté, comme Megalosaurus, que les dents; car les autres pièces osseuses, que l'on rattache à ce genre, y concordent à la vérité par la taille et parce qu'elles ont été trouvée dans les mêmes bancs, mais non dans le même bloc." ‡ The Megalosaurus, in fact, was not the only gigantic reptile which the Stonesfield slate was then known to have contained; but, up to the present time, it has been the sole representative of the Dinosaurian order in that formation; and the combination of the characteristic modifications of the sacrum, scapular arch, and great limb-bones, in skeletons of the same individual of the Iguanodon, and equally proved to coexist in the Hylæosaurus, has added greatly to the probability of the disjoined complex sacrum, dorsal, and lumbar vertebræ, coracoid, and the large hollow femur, from the Stonesfield

* 'Geological Transactions,' vol. i, 2d ser., p. 427.

† Tom. cit., p. 345.

‡ 'Sur le Poikilopleuron Bucklandi,' 4to, p. 52.

slate, which, though Dinosaurian, were neither Iguanodontal nor Hylæosaurian, having belonged to a distinct species of great Dinosaur: to no other reptile, indeed, could the portion of jaw, with teeth manifesting in their structure and mode of implantation the same transitional or annectant characters between the *Crocodilia* and *Lacertilia* as the above-cited parts of the skeleton present, be, with greater probability, referred, than to the peculiar Dinosaurian Carnivore to which the parts of the skeleton above defined certainly belonged.

To my own mind the above reasoning, strengthened by repeated instances of the occurrence of Megalosaurian teeth, with vertebræ, sacrum or portions of sacrum, coracoids, and femora, of the same species as those from Stonesfield ascribed to Megalosaurus, in Wealden and Oolitic formations of other localities, has produced a conviction that the parts to be described in the present part of the Section do belong to one and the same species.

There is, moreover, a peculiar smoothness of surface and compactness of exterior osseous layers, common to the portions of toothed jaws with the other parts of the skeleton, that immediately suggest to the practised anatomical eye the idea of their being specifically identical. The microscopic character of the osseous tissue from the above-named bones is also the same; but on this evidence I should not lay much stress, since the difference is not, at least to me, appreciable between the Megalosaurus, Poikilopleuron, and Streptospondylus, in regard to the microscopic characters of the bone.

The bodies of the sacral vertebræ, as the five vertebræ of the *Megalosaurus* first discovered have proved to be,* are remarkable for their median constriction, and the almost cylindrical form of the transverse section of that part; and the repetition of these and some minor characters in vertebræ of the same size from other parts of the trunk, as, *e.g.*, in a detached dorsal and caudal vertebra obtained from Stonesfield with the original series of Megalosaurian remains, have sufficed for the determination of subsequently discovered and better-preserved specimens of detached vertebræ of the Megalosaurus from other localities.

* Report on British Fossil Reptiles, Part II, 'Trans. of the British Association,' 1841, p. 105.

Dorsal vertebræ. Pl. 24. Nat. size.

The Megalosaurus departs, perhaps even more than does the Iguanodon, from the existing Crocodiles, Monitors and Lizards, in its vertebral characters. The articulating surfaces of the vertebral bodies are very slightly concave, indeed almost flat, presenting in that respect the type of the Amphicœlian Crocodiles: the non-articular surface is remarkably smooth and polished. The centrum is much contracted in the middle, presenting a deep concave outline of the under surface: the margins of the expanded articular extremities are thick and rounded off. The almost cylindrical section of the middle part of the vertebra arises from its being nipped in, as it were, by a more or less deep longitudinal fossa on each side, just below the base of the neural arch; the centrum, however, slightly expanding above the fossa to support the arch.

The length of the base of the neurapophysis is nearly equal to that of the centrum; the suture is persistent, as in Crocodiles; its course is undulating, and it rises in the middle of the centrum. The neurapophysis ascends and inclines outwards, to form, at a height above the centrum equal to three fourths its vertical diameter, the margin of a broad platform of bone, from the sides of which the upper transverse processes (diapophyses) are developed, and from the middle of the upper surface the spinous process. A recent discovery has shown the extraordinary development of the latter apophysis in some of the anterior dorsal vertebræ.

In the Wealden deposits at Battle, Sussex, a large nodule of the ferruginous clay had been formed and consolidated around a portion of the skeleton of a *Megalosaurus* consisting of some anterior thoracic vertebræ. In the state in which this nodule was submitted to my examination, three almost entire and consecutive vertebræ, wanting the ribs, were preserved in natural juxtaposition. A figure of this unique specimen, discovered by S. H. Beccles, Esq., F.G.S., is, with his kind permission, given in Pl. 24 (*Dinosauria*). In a second portion of the same nodule two almost entire and consecutive ribs of the right side were preserved: a smaller fragment contained the bodies and neural arches of two consecutive vertebræ in natural junction from a more anterior part of the chest than the series of the three vertebræ. Two detached vertebræ, wanting the spinous process, from a hinder portion of the trunk, had been obtained either from, or near to, the above-described large nodule.

The three vertebræ (Pl. 24) retain, what is rarely preserved in such complex parts of fossil Saurians, the entire neural spines, *ns*, and exhibit a disposition and

proportions of those parts which have not before been noticed in any Dinosaurian, or in the dorsal vertebræ of any other reptile, recent or fossil.

That these vertebræ are from the fore part of the chest is indicated, according to the analogy of the *Crocodilia* and of the Iguanodon, by the articular surfaces for both the head and tubercle of the rib, and by the progressive ascent of the surface, *p*, for the head of the rib, as the vertebræ recede in position. By reference to the Pl. 24, it will be seen that this surface slightly projects, and is situated upon the neurapophysial suture in the first, *p*, *ns*, but above that suture, supported wholly by the neurapophysis, in the third of those vertebræ, *p*, *ns″*. The megalosaurian character of all of the vertebræ is shown by the great, though regular and gradual constriction of the centrum between its articular ends, by the corresponding depth of the concave contour lengthwise, and by the almost circular form of the transverse section of the lower two thirds of the centrum. The non-articular surface of the centrum is smooth and polished, with some longitudinal grooves and ridges near the expanded ends, the bodies of which are thick and rounded. The side of the centrum is moderately hollowed below the neural suture, and swells out, becoming convex vertically, before bending round to the under surface. There is a rough tuberosity, *t*, at the upper and back part of the centrum, which may be contributed by the base of the neurapophysis.

The neural arch offers the same complex structure as in other *Dinosauria*: a compressed plate, *b*, extends obliquely backward from the parapophysis, *p*, to the diapophysis, *d*; the latter being supported by a stronger buttress extending outward from near the back part of the base of the neurapophysis, and being slightly inclined forward. Three deep depressions, probably receiving parts of the lungs in the living animal, divide these lamelliform buttresses from each other, and from the bases of the anterior, *z*, and posterior, *z′*, zygapophyses. The articular surface of the anterior one looks upward and slightly inward, that of the other, *z′*, downward and slightly outward, both being nearly horizontal. The neural platform extends from the outer margin of the prezygapophyses, *z*, to the fore part of the postzygapophyses, *z′*. The back part of the base of the neural spine is formed by two strong ridges, continued each from the whole upper part of the postzygapophysis, leaving an intermediate fossa for the implantation of a ligament: the base extends forward to the interspace between the prezygapophyses, being coextensive lengthwise with the vertebral centrum.

In the anterior of the three vertebræ the spine, *ns*, as it rises, slightly decreases in fore-and-aft extent, and then as gradually regains its dimension in that direction: after contracting transversely to a thickness of eight lines, when two inches above its base, it gradually expands to a thickness of one inch and a half at its summit, which forms a rough tuberosity, bevelled off obliquely from before upward and backward to within a third of its hinder border, which is flat: the whole height of this spine is nine inches, the vertical extent of the entire vertebra being thirteen inches six lines.

The spine of the second vertebra, *ns*, 1, has a similar size and shape in the basal third of its extent, but it expands more gradually, especially transversely, and rises to a greater height, continuing to expand in every direction, but especially in the antero-posterior one; the fore part of its thick extremity being produced so as to overlap the horizontal part of the end of the shorter spine in front. The sides of the thick expanded end of this clavate spine are impressed by irregular decussating ridges, indicative of the attachment of strong tendons or ligaments; and, from the back part of the side, six inches below the summit, there projects a tuberosity: a less prominent tuberosity forms the border of the overlapping anterior part of the clavate end of the spine. The whole length of the spine is 13 inches 6 lines; the vertical extent of the entire vertebra being 18 inches 6 lines.

The neural spine of the third vertebra, *ns''*, is somewhat smaller than the foregoing at its most contracted part, three inches above its origin; but it expands, as it rises, attains a height of 14 inches, and is divided, like the foregoing, into a smooth part, and a summit impressed by the attachments of the nuchal ligaments or tendons. The base of the latter part developes a tuberosity from the fore part and back part of its outer side, and there are indications of ossifications in the interspace between it and the antecedent spine, which seem to have bound them immoveably together.

The proportions and external configuration of the spines of these anterior dorsal vertebræ, the sudden increase of the second spine, the further increase of the third, with the indications of the strength of the muscles or nuchal ligaments to which their expanded tuberculate summits have given attachment,—all recall characters of the spines of the anterior thoracic vertebræ of certain great Mammalia, and much more closely resemble those parts in the tiger or rhinoceros than in the crocodile, the gavial, or in any of the known existing Lizards. But the production of the summit of the second spine, so as to overlap part of that of the first spine, and the partial anchylosis of the second with the third spine, together with the great increase in the thickness of all the spines toward their summit, are characteristics in a great measure peculiar to the present extinct Dinosaurian; unless, indeed, it participated in them with some other members of the same extinct order of reptiles.

We cannot view this remarkable configuration of the anterior thoracic vertebræ of the Megalosaur without being impressed by an idea of the great strength of the muscles or ligaments—more probably of the energetically contracting muscles—which were implanted in those thick and lofty spines, from which, as from a fixed point, they acted upon the nuchal region of the head. The remarkable fossil, therefore, above described, yields some insight into the vigour with which such a head, consisting chiefly of the well-armed maxillary and mandibular apparatus, must have been made to operate on the bodies which the instincts of the Megalosaurus impelled it to grapple with and destroy in the reiterated predatory or combative acts necessitated for its own support and preservation.

Several specimens of dorsal vertebræ of the Megalosaurus, with the spinous process broken away, have come under my observation. The largest of these, preserved in the Geological Museum at Oxford, gives the following dimensions:

	In.	Lines.
Length of centrum	4	6
Height of ditto	4	3
Breadth of ditto across articular surface	3	9
Breadth of ditto across the middle part	2	6

The proportions and configuration of the neural arch agree with those of the more perfect vertebræ from the Wealden at Battle. The height of the spinous process of this vertebra, according to that marked *ns''* in Pl. 24, would not be less than 18 inches.

The upper part of the centrum is impressed by the spinal canal, which expands at each end, but chiefly behind. One or two vascular canals are sometimes present at the under part of the centrum, but are neither so large nor so regular as in the Plesiosauri.

Compared with the Iguanodon (see Pl. 3, of the Chapter on the 'Fossil Reptiles of the Cretaceous Formations'), the sculptured sides of the neural arch are lower in proportion to their length in the Megalosaur: the anterior zygapophyses are more produced and more angular; the posterior ones are less produced. The depression anterior to the buttress, *d*, is bounded by the converging buttress or ridge, *b*, but this seems not to have been developed in the Iguanodon, in which the nearest approach to it is the elevated parapophysis in certain vertebræ, as in that figured in Pl. 3 (*Dinosauria*), *p*. There does not appear to have been, in the Iguanodon, the depression answering to that in front of the buttress, *b*, in Pl. 24.

It would seem, from the mutilated lumbar vertebræ of the Megalosaurus in the Oxford Museum, figured in Dr. Buckland's original Memoir, pl. xlii, fig. 2, that the anterior oblique buttress, *b*, subsided in the vertebræ in that region.

Sacral vertebræ. Pl. 25.

The sacrum of the Megalosaurus (Pl. 25) consists of five anchylosed vertebræ, and it is remarkable, considering how small a proportion of the recognisable bones of this rare reptile has been found, that the present characteristic part of the vertebral column of three different individuals should have been obtained: one sacrum, from Stonesfield, is in the Geological Museum at Oxford; a second sacrum, from Dry

Sandford, is in the Museum of the Geological Society; and a portion of a third sacrum from the Wealden formation, is in the British Museum.

I have studied each of these specimens with much attention, which a recognition of their remarkable structure has well repaid.

It would seem that Cuvier did not regard the five anchylosed vertebræ, figured in Dr. Buckland's original Memoir,* as the sacrum of the Megalosaurus. They are briefly alluded to in the second and fourth editions of the 'Ossemens Fossiles,' and in the description of the Plate (249, ed. iv, 1836), in which Dr. Buckland's figure is reproduced as a "Suite de cinq vertèbres de Mégalosaurus" (p. 23). In truth, the sacrum was not known to be represented, at that time, in any Saurian by more than two vertebræ, and therefore Dr. Buckland mentions this part in his original Memoir as "five anchylosed joints of the vertebral column, including the two sacral and two others, which are probably referable to the lumbar and caudal vertebræ."†

In contemplating this series of five anchylosed vertebræ, so new in Saurian anatomy, at the period of preparing, in 1840, the 'Report on British Fossil Reptiles,' for the British Association, my attention was first arrested by the singular position of the foramina (Pl. 25, *f, f, f*) for the transmission of the nerves from the inclosed spinal marrow. These holes, which, in the plate illustrating Dr. Buckland's important Memoir, are represented above the bodies of the three middle vertebræ, are natural and are accurately given; the smooth external surface of the side of the vertebra may be traced continuing uninterruptedly through these foramina, over the middle, or nearly the middle, of the centrum, into the surface of the spinal canal.

But the normal position of these foramina throughout the vertebral column in all existing Saurians is at the interspace of two vertebræ, whence by French anatomists these holes are termed "trous du conjugaison." In the sacrum of the Oxford Megalosaur, however, it is evident that above the anchylosed intervertebral space, *i*, a thick and strong imperforate mass of bone, *p*, *d*, ascends to the neural platform, *d*, leaving it to be conjectured either that the nerve had perforated the middle of the neurapophysis, or that these vertebral elements had undergone in this region of the spine a change in their usual relative position to the centrum.

Previous researches into the composition and modifications of the vertebræ in the different classes of Vertebrata soon enabled me to recognise the peculiar condition and analogies of the five anchylosed vertebræ of the Megalosaurus; with a view to illustrate which, I shall premise a few observations, on the different relative positions which the peripheral vertebral elements may take, in regard to the central part or body. The lateral vertebral elements, pleurapophyses, or "vertebral ribs," the inferior laminæ or hæmapophyses, the superior laminæ or neurapophyses, are all subject to such changes; but the neurapophyses are much more constant in their place of attachment than the

* 'Transactions of the Geological Society,' 2d ser., vol. i, pl. 42. † Ib., p. 395.

other elements. In Mammals the ribs for the most part are joined to the interspace of two centrums; in reptiles each pair is attached to a single centrum. In fishes, and the Mosasaur among reptiles, the hæmapophyses depend, each pair from its proper centrum: in most other reptiles and mammals they are articulated to the interspace of two vertebræ, leaving a half-impression on each of the contiguous centrums. The neurapophyses present a degree of constancy in their relation to the body of the vertebra corresponding with the importance of their function. In Mammals I know of no exception to the rule, that each neural arch is supported by a single centrum: among reptiles the Chelonia* offer in those vertebræ in which the expanded spinous processes contribute to form the carapace, the interesting modification analogous to those noticed in the lateral and inferior vertebral elements, viz., a shifting of the neurapophyses from the middle of the body to the interspace of two adjoining centrums, whereby that part of the spine subject to greatest pressure is more securely locked together, and a slight yielding or elastic property is superadded to the support of the neural arch.

The same modification is introduced into the long sacrum of birds;† each neural arch is there supported by two contiguous vertebræ, the interspace of which is opposite the middle of the base of the arch above, and the nervous foramen is opposite the middle of each centrum. It is this structure, beautifully exemplified in the sacrum of the young ostrich, which Creative Wisdom adopted to give due strength to the corresponding region of the spine of a gigantic Saurian species, whose mission in this planet had ended probably before that of the ostrich had begun.

The anchylosed bodies of the sacral vertebræ of the Megalosaur retain the distinguishing characters which have been recognised in the dorsal and caudal vertebræ, in regard to the smooth and polished surface of their middle constricted part; the cylindrical, or nearly cylindrical transverse contour of this part below the lateral depression, *c;* their expanded, thickened, and rounded articular margins, *i;* and also, though in a somewhat less degree, their relative length as compared with their breadth and height. The three anterior sacrals, Pl. 24, 1, 2, 3, are, however, somewhat shorter than the two posterior ones, 4 and 5.

The following are the dimensions of the fifth sacral vertebra:

	In.	Lines.
Antero-posterior diameter of centrum	4	10
Vertical diameter of articular and of centrum	4	1
Transverse diameter of the same part	4	6
Vertical diameter of the middle of the centrum	2	6
Total height of the fourth sacral vertebra	11	0

* Cuvier describes the exceptional structure above alluded to in these reptiles, and likewise cites the Chondropterygians, 'Leçons d'Anat. Comparée,' ed. 1836, tom. i, p. 213.

† 'On the Nature of Limbs,' 8vo, 1849, p. 61, fig. 10.

The neural arches of the first three sacral vertebræ, *ns* 1, 2, 3, have been advanced so as to rest directly over the interspaces of the subjacent bodies; that of the fourth, *ns* 4, derives a greater proportion of its support from its proper centrum, *c* 4; and that of the fifth, which rests by its anterior extremity on a small proportion of the fourth centrum, is extended over nearly the whole length of its own centrum, so that in the caudal vertebræ the ordinary relations of the neural arch and centrum are again resumed. In the first four sacral vertebræ the base of the neural arch extends half way down the interspace between the bodies, and immediately developes from its outer part a strong and short transverse process, or parapophysis, *p*, which is broken and rounded off in the fossil. From the base of this process the neurapophysis expands upward, forward, and backward, is joined by vertical suture to similar expansions of the contiguous neurapophyses, and terminates above in a ridge of bone, *d*, *d*, at right angles to the suture; this ridge, with those of the other neurapophyses, extends longitudinally above the parapophyses the whole length of the sacrum, and forms the margin of the platform from which the spinous and accessory processes are developed: in the last sacrum the corresponding part forms a thick, obtuse process, or diapophysis *d*, 5. The platform is further supported by a compressed ridge of bone extended from the upper part of the parapophyses, like a buttress, to the middle of the horizontal ridge. On each side of the buttress there is a depression, which is deepest in front. The spinous process is not developed, as in the dorsal vertebræ, immediately from the platform, but a shorter, vertical plate of bone, a metapophyses, *m*, of nearly the same longitudinal extent as the true spine, is developed on each side of, and parallel with its base; the height of these metapophyses in the third sacral vertebra is three inches and a half; they incline obliquely outwards, like the metapophyses in the dorso-lumbar vertebræ of the armadillos, and evidently tend to strengthen the connection between the sacral part of the trunk, and the pelvic base of articulation of the hind limbs. The spinous process begins to expand longitudinally, and when nearly opposite the summit of the metapophyses, is joined by vertical suture with the similarly expanded neighbouring spines, so that the sacrum is crowned by a strong continuous vertical longitudinal ridge of bone, at least along the first four vertebræ; the broad spine of the fifth being rounded off anteriorly, and separated by a narrow interspace from that of the fourth. Besides this modification of the spine, and the more normal position of the neural arch, the diapophysis, *d*, of the fifth anchylosed vertebra, resumes its more ordinary shape, and it is supported by two converging ridges of bone from the side of the neural arch below. The origin of the metapophysis, *p*, of the first sacral is placed higher than in the three middle ones, in which the several peculiarities of structure above described are most strongly marked.

The specimens of sacrum of the *Megalosaurus* in the British Museum, and that of the Geological Society, present the same structure as that above described in the original specimen at Oxford. Part of the fifth sacral vertebra is wanting in the

specimen from Dry Sandford. The remaining vertebræ in this specimen are characterised by the same smooth and polished surface, rich brown colour, contraction of the middle of the body, its cylindrical form transversely, and the longitudinal fossa below the annular part, as in the Oxford specimen. The length of this series is one foot six inches and a half; the second and third sacral vertebræ are rather shorte than the rest. The first sacral vertebra, which was not anchylosed to the last lumbar, gives the following dimensions:

	In.	Lines.
Antero-posterior diameter of centrum	5	0
Vertical diameter of anterior articular end	4	0
Transverse diameter of anterior articular end	4	6

The neural arch seems not to have been coextensive in length with the centrum, but rests on its anterior three fourths. A strong and short parapophysis extends obliquely upwards and backwards from each side of the arch; the antero-posterior diameter of the base of this process is two inches, its vertical diameter one inch and a half. In the second sacral vertebra the neural arch has moved forward upon the interspace between the first and second sacral bodies, and developes from the lower part of its base a stronger, thicker, and longer parapophysis, directed outwards and forwards. The third neural arch has its base transferred directly over the interspace of the second and third centrums; the diameters of the base of its parapophyses are three inches and two and a half inches: they incline slightly backwards. The fourth neural arch descends lower down upon the interspace between the third and fourth centrums. The fifth neural arch, as in the Oxford specimen, extends a little way across the interspace between the fourth and fifth centrums, but nearly resumes its ordinary place. The second and third sacral vertebræ are not so regularly convex below in the transverse direction, but their sides converge so as to give a slight indication of a broad obtuse ridge. The diameter of the spinal canal in the first and last sacral vertebræ is one inch.

The specimen of a portion of the sacrum of the Megalosaurus in the British Museum includes one of the sacral vertebræ and a great proportion of the next vertebra. The characteristic shape of the inferior surface of the bodies of these vertebræ is well shown in this specimen, in one of the vertebræ of which the transversely rounded or convex surface begins to be modified into an almost carinate form of that surface. A similar difference of the inferior surface may be noticed in the third and fourth sacral vertebræ of the Iguanodon.*

The five sacral vertebræ are not anchylosed in a straight line, but describe a gentle curve, with the concavity downwards; the series of parapophyses, or sacral ribs, forms

* Pl. 8.

a curved line in the opposite direction, in consequence of their different positions in the several vertebræ. The summits of the anchylosed spines being truncated, describe a curve almost parallel with that of the under part of the vertebræ.

The contour of the hinder part of the body of the present gigantic carnivorous Lizard, doubtless raised high above the ground upon the long and strong hind-legs, must have been different from that of any existing Saurians. In these the relatively shorter hind-legs, being directed more or less obliquely outwards, do not raise the under surface of the abdomen from the ground; it is the greater share in the support of the trunk assigned to the hind-legs in the Megalosaur which made it requisite that, as in the Iguanodon and in land mammals, a greater proportion of the spine should be anchylosed to transfer the superincumbent weight through the medium of the iliac bones upon the femora.

In the caudal vertebræ the parapophyses are suppressed, and the single transverse process is formed by the diapophysis being lengthened out by the anchylosed rudiment of a rib. The hæmal arch was articulated to the lower part of the vertebral interspaces, but chiefly to the anterior vertebra.

Ribs. Pl. 26.

The ribs which, from their size, texture, and colour, as well as from their proximity in the matrix to other more characteristic parts of the Megalosaurus, belong most probably to the same species of reptile as the vertebræ above described, present a double articulation with the vertebral column.

The specimen, fig. 1, from the Stonesfield Oolite, and now preserved in the Museum at Oxford, has a small, almost flattened, obtuse head, *c*, for articulation with a parapophysis; the neck is long, and soon begins rapidly to increase in vertical thickness, being strengthened, also, by a longitudinal ridge on one side. It developes a thick, obtuse tubercle, *t*, larger than the head, for the diapophysis. The body of the rib gradually contracts, with a slight curve, to a point. The length of the body of this floating rib, is little more than twice that of the neck and tubercle, showing that it must have belonged to a hinder cervical or anterior dorsal vertebra.

A second specimen, fig. 2, from the Stonesfield slate, shows a longer body, a neck set on more transversely, and less expanded beneath the tubercle. The upper margin of the neck is sharp; the body of the rib is strengthened by a lateral ridge, and becomes compressed in such a direction that those ridges form its margins towards the lower end; this terminates so as to indicate its having been joined to an abdominal rib.

The upper portion of a rib from a larger specimen of Megalosaurus, and from a more expanded part of the thoracic abdominal cavity, Pl. 26, fig. 3, formed, with fig. 1, part of the original series of fossil bones, from the Stonesfield slate, de-

scribed and referred to the Megalosaurus by Dr. Buckland.* It is remarkable, like the corresponding ribs of the Iguanodon,† for the length and strength of the part between the head, *c*, and tubercle, *t*, called the "neck;" but this presents a different form in transverse section, and a different direction from the neck of the rib in the Iguanodon. The outer border of the body of the rib does not expand below the tubercle, *t*, to form the shield-like plate which characterises the larger ribs of the Iguanodon;‡ the entire body of the rib is more slender, or narrower, but is, perhaps, stronger, from being less flattened and more quadrate, in transverse section; it is strengthened by two low lateral ridges. The relative thickness of the dense, compact outer wall of the rib, to the more open cancellous structure of the central part, which forms what might almost be termed a medullary cavity, near the middle of the body of the rib; and the form of the transverse section of the cervix and body of the rib, are shown in Pl. 26, fig. 3.

Cuvier, in his explanation of the figures introduced into the 'Ossemens Fossiles,' from the original Memoir of Buckland, describes three of the ribs, in the fourth edition (8vo, p. 93) as belonging to "un saurien voisin des crocodiles." It is, in fact, only in the Crocodilian order amongst existing reptiles, that the ribs present a head, neck, and tubercle, coincident with that two-fold articulation with the rest of the vertebra which is associated in the Crocodiles and Gavials with a higher grade of structure of both heart and lungs. The ribs, however, found associated with other parts of the skeleton, including a tooth of the Iguanodon, in the Maidstone quarry of Kentish rag-stone,§ demonstrated that the Crocodilian type of rib was associated with the Dinosaurian modifications of sacrum and limbs in that gigantic reptile: and there can be no reasonable doubt that the like association characterises the skeleton of the Megalosaurus. The minor modifications, above specified, of the huge ribs and fragments of ribs found with portions of jaw, limb-bones, and complex sacrum of answerable magnitude, in the same Oolitic stratum in Oxfordshire relate only to the generic distinctions of the Megalosaurus, as compared with the Iguanodon.

The scapula. Pl. 27.

In the Wealden deposits at Stammerham, Sussex, a scapula of the Dinosaurian type, but differing from the known scapulæ of the Iguanodon and Hylæosaurus, has been discovered by G. B. Holmes, Esq., of the neighbouring town of Horsham, by whom I have been favoured with the drawing lithographed in Pl. 27, fig. 1.

As remains of the Megalosaurus have been obtained from the same locality, some of

* Tom. cit., pl. 43, fig. 1.

† Pl. 7.

‡ Tab. cit., figs. 1 and 2.

§ 'Palæontographical Memoirs,' 1851, Tab. .

which form part of Mr. Holmes's instructive collection, it is possible that the blade-bone in question may belong to that genus; but I insert the description of it here with a full sense of the inadequacy of our present evidence for the precise determination of the scapula of the Megalosaurus.

The body of the bone is an oblong flattened plate, proportionally broader and shorter than in the Iguanodon; with the base rounded, not truncate as in the Hylæosaurus; and with the anterior border at first, as it descends, straight and then concave, not convex, as in the Hylæosaurus. The body of the scapula slightly decreases in breadth as it approaches the articular end, near which there is continued from the anterior border a long and slender process, at least three fourths the length of the entire bone, but the precise proportions of which cannot be determined in this specimen, because the extremity of the process is broken off. Near the base of the process a tuberous projection is developed, which touches the anterior angle of the articular end of the scapula, circumscribing an elliptical vacuity probably for the transmission of vessels. The thickened articular extremity shows indications of a division into two surfaces, one for the coracoid, the other for the humerus.

The coracoid. Pl. 28.

The coracoid is a long and large semioval plate of bone, 2 feet 6 inches in length, 1 foot 4 inches in greatest breadth; with the inner (mesial) border thin and regularly but very slightly convex, the upper border thin and strongly convex, the outer (lateral) border thick and made irregular by the development of processes, grooves, and articular surfaces. The latter are two in number: the largest and deepest, fig. 1, *o, l*, for the head of the humerus, the smallest and shallowest, *o, o*, for junction with the scapula.

This surface, which is hollowed out, groove-wise, chiefly in one direction, is supported by a very strong, thick, three-sided process, *n, o*, a little expanded towards its free end, and contributing by its hinder surface, *o'* to the formation of the glenoid cavity, in front of which it projects to meet the blade-bone. The length of this process is about 6 inches: its circumference is 13 inches; the length of the scapular articular surface, fig. 2, *o*, is 6 inches. A deep oblique notch, fig. 1, *n*, divides the scapular process, *o*, from the thin anterior part of the coracoid, *c, s*, the convex border of which is entire.

In some existing Lacertians, *e, g*, the Monitor and Iguana, a second process is sent off from this part, for articulation through the medium of an epicoracoid cartilage with the episternum; and the mutilated state of the first-discovered specimen of coracoid of the Megalosaurus, figured by Dr. Buckland in pl. xliii, fig. 3, vol. i, 2d series of the

'Geological Transactions,' produced a similar appearance, and led to the belief that the Megalosaurus resembled those Lacertians, in having both the scapular and episternal processes of the coracoid.

Not fewer than three entire or almost entire coracoids of the Megalosaurus have since been obtained, and are now in the British Museum, two of which show the true contour of the anterior part of the bone, as represented in Pl. 28, fig. 1, *c*, *s*. The Megalosaurus, therefore, resembled the Scincoid Lizards and the Crocodiles, in having only the scapular process in its coracoid; approaching, however, to those Lizards and the Lacertians generally in the great breadth of the bone, but more resembling the Crocodiles in the greater development of the scapular process as compared with that in the Scincoids. The glenoid cavity of the coracoid of the Megalosaurus, Pl. 28, fig. 2, *m*, is deeper and larger than in recent Saurians, or than in the Iguanodon. The longitudinal diameter of its outlet is 8 inches in the largest of the three coracoids (purchased by the British Museum of Mr. Stone, from Stonesfield); the greatest transverse diameter of the cavity is 4 inches 4 lines: the internal (central) border of the cavity is moderately sharp and entire; the external (peripheral) border becomes thicker as it recedes from the scapular process, and ends abruptly in an oblong tuberosity; the rest of the outer border beyond this part is thick and rounded, and is continued upon the obtuse process, *l*, forming the hinder boundary of the cavity. This process projects beyond the sharp, almost straight, outer border of the hinder part of the coracoid, which terminates in the hinder angle of the bone.

A strong ridge, like the spine of a scapula, begins to rise from the outer surface of the coracoid, about four inches behind the tubercular termination of the fore and outer part of the glenoid border: it is, at first, thick and rounded, but gradually becomes thinner and more prominent, and is bent outwards and backwards, rapidly subsiding near the hinder angle of the coracoid, and forming the external wall of a wide and deep groove; the internal wall of which is formed by the proper outer and hinder border of the coracoid, fig. 2, *l*. The large proportion of the exterior surface of the coracoid between this process and the anterior border of the bone is slightly concave; the opposite or inner surface being in a less degree convex, or nearly flat. Except a low thick ridge extending from within about four inches of the glenoid cavity to near the lower angle, enlarging as it approaches thereto, the inner surface, fig. 1, is even and almost smooth. Coarse striæ radiate from the articular part of the coracoid to its free expanded border. There is no foramen in any part of the coracoid; none certainly at the base of the scapular process or between this and the glenoid cavity, where such perforation, Cuvier states, may be found in all existing Lizards. If the scapula, Pl. 27, above described should actually belong to the Megalosaurus, the notch or foramen at *e*, fig. 1, may fulfil the function of that which, in the Iguanodon, exists in the coracoid itself.

The clavicle. Pl. 26, fig. 4.

A slender sigmoid bone, nearly two feet in length, from the Stonesfield slate, now in the Geological Museum at Oxford, Pl. 26, fig. 4, was referred, by the discoverer of the *Megalosaurus*, to that species,* from its resemblance to the clavicle in certain Lizards, especially, as Cuvier remarks, who concurs in this determination with Buckland, to the clavicle of the great scincoid Lizard.† It is, however, less bent upon itself than in that existing Saurian, and bears a closer resemblance to the clavicle of the *Iguanodon.*‡ The more expanded median or pectoral extremity of the bone in question has one margin fractured, that which corresponds with the margin from which the two processes are developed in the clavicle of the Iguanodon: how far, therefore, the Megalosaurus resembled the Iguanodon in the form or even existence of those processes cannot at present be determined. The shaft of the clavicle presents a similar gentle sigmoid curve, but is relatively thicker and more bent than in the Iguanodon; its transverse section is subtrihedral: the outer or scapular end is more expanded; the sternal end is more rounded or convex. With respect to the present bone, Cuvier has remarked that according to the proportions of the clavicle in existing Lizards, it bespeaks an animal nearly sixty feet in length,§ but the proportions of the trunk to the limb-bones alter with the increasing bulk in different species of the same family or order, and we shall presently show that there are surer grounds for arriving at the true bulk of the Megalosaurus, than the comparison of its limb-bones with those the small existing Lizards affords.

The ischium. Pl. 26, fig. 5.

The subcompressed, three-sided bone, flattened and expanded at one end, thickened and less expanded at the opposite end, which formed part of a large cotyloid cavity, has most claims to be regarded as the ischium of the Megalosaurus. This bone, now in the Geological Museum at Oxford, formed part of the original series obtained from the Oolitic slate at Stonesfield, and described by Dr. Buckland.||

The longest diameter of the bone is 18 inches; the breadth of the almost straight, thin, mesial border, is about 14 inches, but the angles are somewhat mutilated; the narrow even flattened surface of this border appears to have joined, probably with some interposed fibro-cartilaginous matter, to the corresponding margin of the opposite ischium.

* Buckland, loc. cit., pl. 44, figs. 3 and 4.

† 'Ossemens Fossiles,' 4to, tom. v. pt. ii, p. 347.

‡ Pl. 1, p. 265.

§ 'Ossemens Fossiles,' p. 348.

|| Loc. cit., p. 427, pl. 43, fig. 4.

The femur. Plates 29 and 30.

The fine specimen of this bone, 32 inches in length, of which two views are given in Pl. 29, was discovered in the Oolitic slate at Stonesfield, originally formed part of the rich collection of Fossil Remains belonging to the Earl of Enniskillen, F.R.S., and has recently been transferred, with other parts of the Megalosaurus, from the same collection to the British Museum.

The head is subhemispheric, with the lower margin more freely projecting over or beyond the under part of the neck than appears to have been the case in the Iguanodon.* Viewed from behind, as in fig. 1, or in front, the head of the femur appears to be the convex termination or production of the somewhat expanded and posteriorly flattened upper end of the shaft; but, viewed from the inner side, where the great trochanter, *c*, is seen relieved from the shaft of the bone, the head of the femur has the appearance of being supported by a long and oblique neck, more slender than the shaft. The great trochanter is broad but not much produced, being, as it were, somewhat crushed down upon the shaft. The well-marked groove defining its upper part from the neck, reminds one of that which defines the same part of the upper trochanter in the Iguanodon; but the fissure is narrower and deeper in that Dinosaur than in the present genus. The inner trochanter, Pl. 29, *d*, is situated higher up, and is less produced than in the Iguanodon: it has also a broader base, which is extended further upon the hinder surface of the shaft of the femur. I have not seen any femora of the Megalosaurus in which the two trochanters were so nearly opposite one another, as is represented in the figures of that bone given in Dr. Buckland's original Memoir: the upper end of the specimen from which that figure was taken, had been more mutilated than in the original of the figures in Pl. 29. Below the inner trochanter the shaft of the femur assumes a subquadrate transverse section, with the angles rounded; and, near the lower end, begins to expand into the condyles. The anterior or rotular interspace, Pl. 30, *g*, is much less deep, and is broader than in the Iguanodon; the posterior or popliteal interspace, *ib. h*, more resembles in size and depth that in the Iguanodon, but it is more flattened at the bottom. The outer condyle, fig. 1, *f*, has a moderately deep and wide longitudinal impression externally, which marks off the hinder projecting part of the condyle, which is relatively narrower than in the Iguanodon; the inner condyle, *e*, which is the largest and most prominent of the two, is almost flat upon its inner side. The figure, of the natural size, of the distal condyles, in Pl. 30, taken from the best preserved specimen of the femur of the Megalosaurus in the British Museum will serve better than verbal description to convey a just idea of the modifications of this articular end of the bone in question.

* See 'Dinosauria,' pl. 20.

The tibia. Plate 31.

The specimen, from which the reduced figures have been taken in the above plate, is the most perfect one of the tibia of the Megalosaurus which has hitherto come under my notice: it originally formed part of the collection of Megalosaurian remains from the Stonesfield slate, acquired by the Earl of Enniskillen, whilst an undergraduate at Oxford, and is now in the British Museum.

Fig. 1 gives a side view of the bone, with a top view of the upper articular surface. The divisions corresponding with the condyles of the femur project from the back part of the proximal end, which gradually contracts towards the fore-part where it assumes the character of a process, answering to the procnemial ridge in the tibia of birds, but it is a little inclined inward. The articular surface is a little concave at its middle part and becomes convex, in a moderate degree, upon the condyles. A thick cartilage appears to have covered the whole of this surface, and the softer bone in contact with the cartilage has been, as in most fossil reptilian long bones, more or less abraded, especially at the margins of the articulation. The backward position and production of the corresponding articular prominences or condyles in both femur and tibia, indicate that these bones were joined together at an angle, probably approaching a right one, when in their intermediate state between flexion and extension: and that motion of the tibia in the latter direction could not have taken place to the extent required to bring the two bones in the same line. A moderately developed longitudinal ridge, fig. 2, *c*, extends from the inner side of the upper fourth of the shaft of the tibia, the homologue of which is present in the tibia of the great Monitor. Below this the shaft of the tibia assumes a sub-trihedral figure, with the angles unequally rounded off, fig. 3; it very gradually decreases in breadth, from before backwards, to within a short distance of the lower end: the transverse diameter remains the same. The expansion of the lower articular end is chiefly in the latter direction, *i. e.*, at right angles with the long diameter of the proximal end: the inner angle of the distal end is the most produced. The form of the articular surface for the tarsus is a rhomboid, with two shallow depressions, but in the main is moderately convex.

The length of the bone above described is 26 inches: its shaft, like that of the femur, has a medullary cavity, but the compact walls are relatively thicker in the tibia.

The above-described bone, from the Oolitic slate of Stonesfield, presents all the main Dinosaurian characters, which have been described, in a preceding section, in the tibia of the *Iguanodon*.* From that tibia the present bone differs in its

* P. 313.

greater relative slenderness and its better developed processes, especially the inner, or entocnemial, ridge. The differences are of that degree which might be expected to be found in a limb-bone of another species or genus of large Dinosaurian reptile; and no reptile answering to that character has yet been determined, by fossil remains from the Stonesfield Oolitic slate, except the Megalosaurus. The modifications in question are such, moreover, as accord with the superior energy and activity which a carnivorous reptile like the Megalosaurus might be expected to possess in contrast with the heavier and more bulky herbivorous Iguanodon. There can be no reasonable doubt, therefore, that we have, in the subject of Pl. 31, the veritable leg-bone or tibia of the Megalosaurus.

Portions of metatarsal bones, most probably from their size and texture, those of the Megalosaurus, have been obtained from the Stonesfield Oolite and Sussex Wealden: one of these is figured by Dr. Buckland in Pl. xlix, fig. 6, of the volume of the 'Geological Transactions' containing his original Memoir on the *Megalosaurus.*

These fossils, however, which I have examined in the Geological Museum at Oxford, do not present sufficiently marked characteristic modifications to render a special description of them serviceable for the identification of future specimens of *Megalosauri.*

Ungual phalanges. Plate 32.

Both teeth and vertebræ of the Megalosaurus have been discovered in the Wealden strata which contain remains of the Iguanodon and other large reptiles. Besides the claw-bones which, from their broad, obtuse, massive and slightly curved shape, I have referred to the herbivorous Iguanodon, there have been obtained, also from the Wealden, claw-bones which, by their sub-compressed, curved, and sharp-pointed shape indicate a carnivorous reptile; and some of these, by their size, might well belong to the Megalosaurus.

Without, however, the association of such claw-bones with other parts of the limb, recognisably Megalosaurian, a certain conclusion of their nature cannot be arrived at. The probability, however, of this latter type of ungual phalanx being that which the Megalosaurus would exhibit, decides me to give the requisite illustrations of it in the present section of this work.

Pl. 32, figs. 1 and 2, give side views of an ungual phalanx, wanting the tip, and with a portion of matrix attached to the base. The length of this phalanx, if the point be restored according to the pattern of the smaller and better preserved specimen of the same kind, fig. 5, would be between 5 and 6 inches: the depth of the base of the phalanx is 2 inches 9 lines; the extreme breadth of the base being but 1 inch 5 lines.

The articular surface is deeply concave in the vertical direction, indicative of a strong joint and a certain extent of vertical motion, or of retraction and protrusion. Beneath the articular surface is a large rough process or protuberance for the insertion of a powerful flexor tendon. The margin of the articular pulley is slightly raised and roughened, for the attachment of the capsular ligament. The base of the claw-bone is longitudinally striated; the rest of the surface is smooth, and offers the same compact character and colour which are commonly found in the bones of the Megalosauri. On each side of the bone, nearer the lower border, and rather lower down on one side than on the other, is a deep smooth groove, running parallel with the lower concavity of the bone. These grooves indicate the position of the borders of the horny matter of the claw, and also, of the vessels supplying the reproductive matrix of that matter.

A smaller phalanx of the same type with one side imbedded in a block of Wealden sandstone, fig. 5, shows the whole length, and the sharp-pointed termination of the bone supporting the formidable claw.

Both the above-described specimens are in the British Museum.

Mandible and Teeth. Plates 33 and 34.

The most important evidence of these highly characteristic parts of the Megalosaurus is the portion of the dentary element of the mandible or lower jaw, from the Stonesfield slate, preserved in the Geological Museum at Oxford, and forming part of the original series of bones described by Dr. Buckland.* This specimen is represented, of the natural size, in Pl. 33, fig. 1, from the inner side: a portion of the outer side of the same specimen is given in fig. 2. The entire depth of the ramus of the jaw is not, however, represented by this specimen: a broad and shallow groove along the under and inner surface of the bone indicates where the angular element of the mandible had articulated with this hinder portion of the dentary piece. The portion of the dentary element from a more advanced part of that bone, represented in Pl. 34, affords a truer idea of the vertical diameter of the mandibular ramus of the Megalosaur.

The first character which attracts the attention of the anatomist, in the Oxford specimen (Pl. 33, figs. 1 and 2), is the inequality in the height of the outer and inner alveolar walls. This assures him of the saurian affinities of the gigantic reptile; a similar inequality characterising the jaws of almost all the existing Lizards. But in these the oblique groove, so bounded, to which the bases of the developed teeth are anchylosed, is much more shallow, and is relatively wider; and the teeth, in all their stages of growth,

* Loc. cit., pl. 40.

are completely exposed, when the gum has been removed. In the Megalosaur the greater relative development of the inner alveolar wall narrows the groove, and covers a greater proportion of the bases of the teeth, besides concealing more or less completely the germs of their successors. Moreover, instead of the mere shallow impressions upon the inner side of the outer alveolar plate, to which the teeth are attached in modern Lizards, there are distinct sockets formed by bony partitions connecting the outer with the inner alveolar walls in the jaw of the Megalosaurus.

These partitions rise from the outer side of the inner alveolar wall in the form of triangular vertical plates of bone, having their plane parallel with that of the inner wall; and from the middle of the outer side of each plate a bony partition crosses to the outer parapet, completing the alveoli of the fully-formed or more advanced teeth, the series of triangular plates, *t*, *t*, fig. 1, forming a kind of zigzag buttress along the inner side of those alveoli. The outer parapet rises an inch higher than the inner one.

Of the fully-developed teeth only one had been preserved *in situ*, in the specimen under description; the others appear rather to have slipped out, than to have been broken off, the anchylosis of the basal capsule of the tooth to the alveolar periosteum being but slight, and apparently taking place tardily in the Megalosaurus.

This tooth, Pl. 33, fig. 1, *a*, exhibits the average size of the fully developed teeth of the Megalosaurus that have yet been discovered. The shape of the crown is well exemplified in this figure, and in figs. 2, 4, and 5 of Pl. 34. It is sub-compressed, slightly recurved, sharp-edged and sharp-pointed; the edges being minutely serrated: the edge upon the convex or front border becomes blunted as it descends about two thirds of the way towards the base of the tooth; that upon the concave hinder border it is continued to the base. The lower half of the crown is thicker towards the fore-margin than towards the hind one, so that a transverse section gives a narrow oval form pointed behind, as in the lower section of fig. 5, Pl. 34: at the upper half of the crown the sides slope more equably from the middle thickest part to both margins, and the section is a narrow pointed ellipse, as in the upper section of the same figure. The crown is covered by a smooth and polished enamel which wholly forms the marginal serrations. The base of the tooth is coated with a smooth lighter-coloured cement, forming a thin layer, and becoming a little thicker towards the implanted end of the tooth. The remains of the pulp are converted into osteodentine in the basal part of the completely formed tooth. Moderately magnified, the surface of the enamel presents a finely wrinkled appearance. The marginal serrations present, under a somewhat higher power, the form shown in fig. 12, Pl. 33; their points being directed towards the apex of the tooth, a structure well adapted for dividing the tough tissues of the saurian integument. The main body of the tooth consists of dentine, of that hard, unvascular kind of which the same part of the teeth of existing Crocodiles and most mammals is composed. The dentinal tubules, in the Megalosaurus, are extremely fine and close-set, presenting a diameter of $\frac{1}{28,000}$th of an

inch, with interspaces varying between two and three times that diameter. They radiate from the pulp-cavity at right angles with the external surface of the tooth. The primary curvatures correspond with those of the dentinal tubules in the *Varanus*, figured in my 'Odontography,' pl. 67, fig. 2; but they are less marked, so that the tubules appear straighter in the Megalosaurus. After their origin they dichotomize sparingly, but the number of minute secondary branches sent off into the intermediate substance is very great. These secondary branches proceed at acute angles from the primary tubules; the divisions of the latter become very frequent near the periphery of the dentine, and the terminal branches dilate into, or inosculate with, a stratum of minute calcigerous cells, which separates the dentine from the enamel.* No part of the dentine is pervaded by medullary canals, as in the Iguanodon.

A series of teeth from individual Megalosauri of different ages has been selected from specimens in the British Museum, and in the Geological Museum at Oxford, progressively diminishing in size, but preserving the same characteristic form, from fig. 4 to fig. 9, inclusive, Pl. 33. Fig. 3 shows a specimen, imbedded in Stonesfield slate, which shows a somewhat more slender termination than usual. Fig. 11 is a much-worn and shed tooth, apparently of a small-sized Megalosaurus, in which both the point and the trenchant margins had been rubbed down to a smooth obtuse surface: it may have come from the hinder part of the dental series, where the teeth may have been smaller and less sharp, or more liable to be blunted by a greater share in the imperfect act of mastication than the teeth in advance.

Successional teeth, in different stages of growth, are shown in the original portion of jaw of the Megalosaurus in the Oxford Museum. Some more advanced, as at *b*, fig. 1, Pl. 33, show their crowns projecting from alveoli already formed by the plate extending across from the triangular processes before described. Vacant sockets from which fully formed teeth have escaped occur, generally in the intervals between these more advanced teeth. The summits of less developed teeth are seen protruding, as at *c*, *c*, at the inner side of the basal interspaces of the triangular plate, between them and the true internal alveolar parapet. There can be no doubt that, in the course of the development of these teeth, corresponding changes take place in the jaw itself, by which new triangular plates and alveolor partitions are formed, as the old ones become absorbed, analogous to these concomitant changes in the growth and form of the teeth, alveoli, and jaws, which take place in so striking a degree in the Elephant.†

The peculiarity of the Megalosaurus, as compared with the Crocodiles and Lizards

* The microscopic characters of the tooth of the Megalosaurus are represented in my 'Odontography,' pl. 70 A, in part of a transverse section of the middle of the crown, including the pulp-cavity and its osteo-dentine.

† See 'Odontography,' p. 625.

which have a like endless succession of teeth, is the deeper position of the successional tooth in relation to the one it is destined to replace, and the great proportion of the tooth which is formed before it is protruded. This interesting character is well exhibited in a portion of the jaw, kindly submitted to my examination by His Grace the Duke of Marlborough, and which is figured in Pl. 34, fig. 1. The anterior tooth, *a*, in this specimen, shows, at the inner side of its base, the commencing absorption stimulated by the encroaching capsule of the successional tooth below, the crown of which is completed externally, though not consolidated. On one of the fractured margins of this piece of jaw a part of the basal shell of an absorbed and shed tooth remains at *a*, fig. 3, with part of the root of the successional tooth which has risen into place, *b*; but which shows its base full of matrix, the pulp not having been calcified at that period of the tooth's growth. The crown of a third tooth, *c*, incompletely calcified, is exposed beneath, in the substance of the jaw. In fig. 1, the germs of several successional teeth are shown at *c*. In the proportion of the successional teeth which is calcified in the formative cavity in the substance of the jaw, the Megalosaurus offers a closer resemblance to the Mammalian class than do any of the recent or extinct Crocodilian or Lacertian reptiles. But the evidence of uninterrupted and frequent succession of the teeth in the Megalosaurus is unequivocal, and this part of the dental economy of the great carnivorous Reptile is strictly analogous to that which governs the same system in the existing members of the class. The different forms of the teeth at different stages of protrusion did not fail to attract the attention of the gifted discoverer of the *Megalosaurus*, in whose words I will conclude this part of my Monograph on the most formidable of extinct British Reptiles.

"In the structure of these teeth we find a combination of mechanical contrivances analogous to those which are adopted in the construction of the knife, the sabre, and the saw. When first protruded above the gum, the apex of each tooth presented a double cutting edge of serrated enamel. In this stage, its position and line of action were nearly vertical, and its form, like that of the two-edged point of a sabre, cutting equally on each side. As the tooth advanced in growth it became curved backwards in the form of a pruning-knife, and the edge of serrated enamel was continued downwards to the base of the inner and cutting side of the tooth, whilst on the outer side a similar edge descended but a short distance from the point, and the convex portion of the tooth became blunt and thick, as the back of a knife is made thick for the purpose of producing strength. The strength of the tooth was further increased by the expansion of its side. Had the serrature continued along the whole of the blunt and convex portion of the tooth, it would in this position have possessed no useful cutting power; it ceased precisely at the point beyond which it could no longer be effective. In a tooth thus formed for cutting along its concave edge, each movement of the jaw combined the power of the knife and saw; whilst the apex, in making the first incision, acted like the two-edged point of a sabre. The backward curvature of the full-grown

teeth enabled them to retain, like barbs, the prey which they had penetrated. In these adaptations we see contrivances which human ingenuity has also adopted in the preparation of various instruments of art."*

Size of the Megalosaurus.

A few words may be added touching the size of the Megalosaurus; for it appears to me that the calculations which assign to it a length of 60 and 70 feet are affected by the fallacy of concluding that the locomotive extremities bore the same proportion to, and share in the support of, the body, as they do in the small modern land Lizards.

The most probable approximation to a true notion of the actual length of the Megalosaurus is that which may be obtained by taking the length of the vertebræ as the basis. The antero-posterior dimension is the most constant which the vertebræ present throughout the spine: in most Crocodilian and Lacertian reptiles the cervical vertebræ are a little shorter than the dorsal; but these are of equal length, and the caudal vertebræ maintain the same length, though decreasing in other dimensions, to very near the extremity of the tail.

As the dorsal vertebræ of the Megalosaurus agree, in the important character of the mode of articulation of the ribs, with the Crocodiles, it may be regarded as most probable that they also corresponded in their number. This does not exceed 14 in recent Crocodiles, nor 16 in any of the known extinct species; taking, then, the latter number, and adding to it 7, the usual number of the cervical vertebræ in Crocodiles, we may allow the Megalosaurus 23 vertebræ of the trunk.

The length of the body of a large dorsal vertebra of the Megalosaurus, in the British Museum, is $4\frac{1}{2}$ inches: from the analogy of the Iguanodon I was led, in my original calculations,† to allow a probable thickness of the intervertebral substance one third of an inch: but if we multiply 23 by 5, not allowing for the probable shortness of the cervical vertebræ, we only then attain a length of 9 feet 7 inches. The subsequent discovery of the coadapted dorsal vertebræ, figured in Pl. 24 (*Dinosauria*), shows that their bodies were not separated by soft substance of more than 1 line in thickness. If, moreover, setting aside the analogy of the Megalosaurus to the Crocodiles in the structure of the vertebræ, we take that species of Lacertian which it most resembles in the structure of the teeth, and found our calculation on the number of vertebræ of the trunk in such Lizard, then, the great carnivorous Varanian Monitor

* Buckland, 'Bridgewater Treatise,' vol. i, p. 237.

† Report on British Fossil Reptiles, 'Trans. Brit. Association,' 1841.

of Java having 27 vertebræ of the trunk, we do not, even calculating the same number of vertebræ to have occupied each a space of five inches in the Megalosaurus, obtain a length of trunk exceeding 11 feet 3 inches.

I should consider the first calculation, or about 10 feet, to have been more nearly the natural length.

To this we must add 2 feet for the known length of the sacrum. Thus 12 feet will be a fair or even a liberal allowance of length from the occiput to the beginning of the tail. In Crocodiles the skull equals about 12 dorsal vertebræ in length. In the Java Monitor the proportion of the head is less. In the Iguana the cranium does not exceed 6 dorsal vertebræ in length.

We may consider therefore 5 feet, taking the Crocodile as the term of comparison, as probably not below the length of the head of the Megalosaur. With regard to the tail, this includes between 36 and 38 vertebræ in Crocodilians, but varies from 30 to 115 vertebræ in the small existing Lacertians, in many of which it is a prehensile organ, aiding them in climbing and other actions suitable to their size. It is very improbable that the tail should have presented such unusual proportions in the great Saurian under consideration, and indeed very few caudal vertebræ of the Megalosaur have been as yet discovered, and none exceeding 4 inches in length. Allowing the Megalosaur to have had the same number of caudal vertebræ as the Crocodile, and multiplying this number, viz. 36, by $4\frac{1}{2}$, a length of 12 feet 6 inches is thus obtained for the tail. A calculation on this basis thus gives, in round numbers,—

	Feet.
Length of head	5
Length of trunk, with sacrum	12
Length of tail	13
Total length of the Megalosaurus	30

Upon this mode of obtaining an idea of the bulk of the present extinct reptile I am disposed to place the greatest reliance, and conceive that any error in it is more likely to be on the side of exaggeration than of curtailment. From the size and form of the ribs it is evident that the trunk was broader and deeper in proportion than in modern Saurians, and it was doubtless raised from the ground upon extremities proportionally larger and especially longer, so that the general aspect of the living Megalosaur must have proportionally resembled that of the large terrestrial quadrupeds of the Mammalian class which now tread the earth, and the place of which seems to have been supplied in the oolitic ages by the great reptiles of the extinct Dinosaurian order.

Strata and Localities of Megalosaurian Remains.

Besides the Stonesfield slate, the remains of the Megalosaurus have been found in

the Cornbrash and Bath Oolite immediately above that slate, and in Oolites beneath it. A tooth of a Megalosaurus has been kindly communicated to me by Mr. Woodward, of the British Museum, which was found in the Inferior Oolite of Selsly Hill, Gloucestershire, which is separated from the Stonesfield Oolite by superimposed deposits of Fullers' earth one hundred feet in vertical extent. Vertebræ and parts of long bones of the Megalosaurus have been found in the Inferior Oolite at Kingham, near Chipping-Norton, and at Broadwell, near Merke-in-the-Marsh, Gloucestershire. But the formation in which the remains of the Megalosaur occur, in quantity only inferior to those in the Stonesfield slate, is the Wealden strata. Dr. Mantell discovered in the ferruginous clay of the Forest of Tilgate a fine vertebra, and a portion of the femur of the Megalosaurus, 22 inches in circumference. Some fragments of the metacarpus and metatarsus from this locality, were thicker than those of a large hippopotamus. Many teeth, of the same form as those found by Dr. Buckland, at Stonesfield, have been obtained from Wealden strata. Mr. Holmes, surgeon, at Horsham, possesses a good caudal vertebra, and some other parts of the Megalosaurus from the furruginous sand near Cuckfield, in Sussex. The magnificent specimen of dorsal vertebræ, T. xix, *loc. cit.*, was discovered by Mr. Beckles, F.G.S., in the Wealden formation near Battle. Remains of the Megalosaurus occur in the Purbeck Limestone at Swanage Bay. In some of the private collections in the town in Malton, Yorkshire, are teeth, unquestionably belonging to the same species as the Stonesfield Megalosaurus, from the Oolite in the neighbourhood of that town.

ORDER—*DINOSAURIA*.

Genus—HYLÆOSAURUS,* *Mantell.*

THE third well-marked genus of Dinosaurian Reptiles, referred to in the foregoing division of the present chapter,† is founded upon a large portion of the skeleton of one and the same individual (Pl. 35), to which the name at the head of this section has been applied by its discoverer, Dr. Mantell.

In assigning to this genus a place in the Dinosaurian order, I have been guided by the structure of the vertebral column, especially the sacrum (Pls. 36 and 37), and, in placing it after the Megalosaurus, by the following considerations. The distinct alveoli in the jaws of the Megalosaurus, and the resemblance of its teeth to those of two extinct Crocodilians, viz., the Argenton species‡ and the Suchosaurus,§ seemed to claim for that great carnivorous Dinosaur a higher position, or one nearer to the Crocodilian order. In the present genus, which there is good reason for believing to have resembled the Lizards more than the Crocodiles in its dental characters, an affinity to the *Crocodilia* is, however, manifested not only by the structure of the vertebræ and ribs common to it with other Dinosaurs, but likewise by the presence of dermal bones, or scutes, with which the external surface was studded.

The Hylæosaurus has not been made known like the Megalosaurus, from detached parts of the skeleton successively discovered and analogically recomposed, but was at once brought into the domain of palæontology by the discovery of the following parts of the skeleton in almost natural juxtaposition (Pl. 35), viz., the anterior part of the trunk, including ten of the anterior vertebræ in succession (3—10), supporting a small fragment of the base of the skull; the two coracoids (ib., 52), the coracoid extremities of both scapulæ (ib., 51), detached vertebræ, several ribs (ib., *pl*) more or less complete, and some remarkable parts of the dermal skeleton, including enormous vertical plates or spines (ib., *d, d*), arranged, as it appears, in the form of a median dorsal ridge or crest of singular dimensions.

This specimen is now in the British Museum. It was discovered in 1832, in a block of stone, measuring 4½ feet by 2½ feet, in the Wealden of Tilgate, Sussex.||

In the fragment of the cranium may be distinguished the pterygoid elements of the

* ὑλαῖος, *sylvestris*, belonging to a wood, σαῦρος, lizard.

† Page 329.

‡ 'Crocodile des Marnières d'Argenton,' Cuvier, Ossemens Fossiles, 8vo, 1836, tom ix, p. 331, pl. 238, figs. 14, 15, 16.

§ 'Odontography,' p. 287, pl. 62 A, fig. 10.

|| 'Proceedings of the Geological Society,' December 5th, 1832, vol. i, p. 410.

sphenoid bone, the inner margins of which touch anteriorly and then recede as they pass backwards, leaving a heart-shaped posterior nasal aperture, the apex of which is turned forwards. The breadth of this aperture is 1 inch 3 lines: its posterior position gives another character by which the present Dinosaur, and probably the larger genera of the same order, resembled the Crocodiles more than the Lizards.

The bodies of the vertebræ are shorter in proportion to their breadth than in the Megalosaurus or Iguanodon. They have not so smooth and polished a surface as in the Megalosaurus, nor are they so contracted in the middle, or so regularly rounded below from side to side; a few of the anterior vertebræ are somewhat flattened below, so as to present an obscurely quadrate figure; most of the anterior dorsals (Pl. 35, figs. 10 and 11) are more compressed and keel-shaped below; the sacral (Pl. 36) and many of the caudal vertebræ (Pl. 41) are longitudinally sulcated at their under surface.

The structure of the atlas and axis cannot be discerned in the British Museum specimen; the second (conspicuous) cervical vertebra (Pl. 35, 4)* has its sides subcompressed, its under surface rather flattened anteriorly, and the slight angular ridges separating it from the concave lateral surfaces are produced anteriorly into two feebly marked tubercles. The parapophyses, or inferior transverse processes, are developed from each side of the anterior part of the body of the vertebra; they are subcircular, very slightly prominent, about 7 lines in diameter.

In the fourth (conspicuous) vertebra (Pl. 35, 6)* a parapophysis is, also, developed from each side of the anterior part of the body, with the costal surface directed obliquely outwards and forwards. There is a small costal surface at the side of the expanded posterior extremity of the same vertebra, against which a part of the head of a rib abuts; that and three of the succeeding ribs having their heads applied over the interspace of two contiguous vertebræ, as nearly throughout the thoracic region in Mammalia.

The lateral compression of the centrum increases in the sixth (8) and seventh (9) (conspicuous) vertebræ, in which the under surface forms an obtuse ridge; in the eighth vertebra (10) this surface is broader and more rounded. In none of these vertebræ is a process developed from the under surface, as in the hinder cervical and anterior dorsal vertebræ of the Crocodiles; and in none of them is the anterior articular surface of the centrum convex, as in the Streptospondylus.

The most striking character of the vertebræ of the Hylæosaurus is the great development of the neural arch and its processes. The anterior articular processes extend (in the anterior dorsal and cervical vertebræ) over half the centrum next in front, and a broad diapophysis (upper transverse process) is developed from the side

* The Arabic numerals indicate the position which I believe the vertebræ to have had in the entire series forming the back-bone of the Hylæosaur.

of the neurapophysis and along its anterior continuation: the diapophysis extends horizontally outwards, is notched anteriorly, and contracts to an obtuse point, against which the tubercle of the rib articulates: it is flat transversely, slightly concave lengthwise, and smooth below. The diapophyses increase in length and strength as the vertebræ extend along the trunk; and the ribs, which they contribute to support, exhibit a still more rapid increase. The ribs present, as in the other Dinosaurs and Crocodiles, a bifurcated vertebral end, for the double articulation above described (Pl. 35, *pl* 3, and the ribs attached to 9 and 10). The rib (*pl* 2) which appears to be the second, and belongs to the cervical region, is short and pointed, not exceeding 4 inches in length. The neck and head of the rib corresponding with the seventh conspicuous vertebra, apparently the third free rib (*pl* 3), is 2 inches 2 lines in length; the tubercle, or upper head, is 10 lines long; the breadth of the rib at the point of bifurcation is 1 inch 1 line; the entire length of this rib is $5\frac{1}{2}$ inches. The neck of the fourth rib (*pl* 4) has the same length as that of the third, but is twice as thick and strong; the tubercle is broader but shorter. Beyond the tubercle the shaft of the rib is bent at nearly right angles with the neck. This soon begins to shorten, and the shaft of the rib to lengthen, until it becomes attached solely to the diapophysis.

In the dorsal vertebræ the body increases in all its proportions, excepting its length. The lateral compression now manifests itself at the upper part of the centrum, just below the neurapophysial suture; the under surface of the posterior dorsal and lumbar vertebræ is convex transversely, but in a less degree than in the Megalosaurus, and in some it is obscurely carinated. The external surface at the middle contracted part of the vertebra is moderately smooth, but the minute striæ give it a somewhat silky lustre; it is longitudinally but irregularly ridged and grooved near the articular ends. These are both slightly concave at the centre, more slightly convex near the circumference.

The difference between the vertebræ of the Hylæosaur and the biconcave Crocodilian vertebræ is chiefly manifested in the development of the neural arch. The modification of this part in the cervical vertebræ has already been mentioned. In the dorsal vertebræ (Pl. 39, fig. 10) each neurapophysis rises vertically, contracting in the axis of the vertebra, expanding transversely or outwardly, until it has attained a height equal to that of the centrum; there it expands into a broad and flat platform (*d*), from the middle line of which the broad spine (*ns*) is developed. A vertically compressed but strong diapophysis (*d*) is developed from the side of the neurapophysis, and is supported by a pyramidal underprop (*t*), extending upwards and outwards from the anchylosed base of the neurapophysis. There is a large deep and smooth depression (*p*) on each side of the base of the diapophysis. The anterior surface of the neural arch, above the anterior oblique processes, or prezygapophyses (*z*), is traversed by a vertical ridge, on each side of which there is a shallow

depression.* The spinous process (*ns*) is of unusual thickness; its transverse breadth at the base measures 1 inch: this modification may probably relate to the support of great dermal spines. The spinal canal in the dorsal vertebræ is cylindrical, and expanded at both extremities; its diameter at the middle is 7 lines, at the expanded outlets 10 lines, in a posterior dorsal or lumbar vertebra. Here the bases of the neurapophyses begin to shorten, and leave a small proportion of the upper surface of the centrum uncovered at both ends, chiefly at the posterior end.

The following are dimensions taken from three of the vertebræ in the portion of the skeleton of the Hylæosaurus (Pl. 35):

	Vertebra No. 4.		Vertebra No. 6.		Middle dorsal.	
	In.	Lin.	In.	Lin.	In.	Lin.
Length, or antero-posterior diameter of centrum . .	1	10	2	2	2	9
Height, or vertical diameter of its articular end . .	0	0	1	6	2	6
Breadth, or transverse diameter of its articular end .	2	0	2	2	3	0
Transverse diameter of middle of centrum . .	0	0	0	0	2	0

The differences between the vertebræ of the Hylæosaurus and Megalosaurus have been already pointed out, and are further shown in the admeasurements given above.† The vertebræ of the Hylæosaurus differ from those of the Iguanodon in their greater relative transverse diameter, and in the greater breadth of their under part; those of the Iguanodon are flatter vertically along their whole sides, which converge to a narrower ridge at the under part. The vertebræ of the Hylæosaurus differ from those of the Streptospondylus in the sub-biconcave character of both the articular ends of the centrum: the separated neural arch might be distinguished from that of the Streptospondylus by the simplicity of the supporting buttress of the transverse process; and, although equal in height, yet is superior in the expansion and strength of the platform and spinous process. From the vertebræ of the Poikilopleuron, an oolitic Saurian of about the same bulk, those of the Hylæosaurus differ in their more compact osseous structure, and in the absence of the large cells that characterise that structure in the vertebral bodies of the Poikilopleuron.

The Sacrum (Pls. 36 and 37).

There is a portion of a sacrum of a small or young Dinosaur (Pl. 37, fig. 1, No. $\frac{484}{2484}$, British Museum), which, in the form and proportions of the bodies of the vertebræ, most resembles the present genus, and cannot be referred to either the Megalosaurus or Iguanodon. It includes two entire and parts of two other vertebral

* This description is taken from Nos. 2586 and 2125, parts of the same vertebra, in the British Museum.

† Compare with those given at p. 335.

bodies, anchylosed together, and to the bases of the neurapophyses, which, as in the Megalosaurus, are transferred to the upper and lateral parts of the interspaces of the subjacent bodies. These are moderately, but regularly, contracted in the middle and chiefly laterally, being more flattened below, where likewise each is traversed by a longitudinal sulcus. At the middle of each lateral concavity there is a vascular perforation. I am uncertain which is the anterior part of this interesting series; but, by the analogy of the Megalosaurus, conclude that vertebra which supports the greatest proportion of its neural arch to be posterior to the adjoining one which supports the remaining small proportion. On this basis also I assume that the anterior sacral vertebra is deficient, if we may allow five to the Hylæosaur as to the other Dinosaurs.

The second sacral vertebra, then, is here broken across the middle of the body, exposing its solid minutely cellular central structure: its neural arch is too mutilated for profitable description: its base rests nearly equally on the second and third sacral bodies. The third neural arch, which exhibits a similar relative position, has its base extended half way down the vertebral interspace; its strong transverse process, diapophysis and pleurapophysis combined, extends outwards and forwards, and is at first contracted, then expands both transversely and vertically, most so in the latter direction, and is twisted obliquely, so that the lower end is directed downwards and forwards, and the upper and thicker end is bent obliquely backwards, until it meets and becomes anchylosed to the anterior production of the transverse process of the next vertebra behind: an elliptical space is thus produced, the axis of which is nearly vertical, and into this space the neural canal opens; the nerve being transmitted over the middle of the body of the vertebra, as in the sacrum of the Megalosaurus and Iguanodon.

The upper and inner part of the base of the broad, oblique transverse process, or sacral rib, abuts against the base of the spinous process. There is no appearance of accessory spines or metapophyses, such as the sacrum of the Megalosaurus is complicated with.

The following are admeasurements of the present portion of the sacrum of the Hylæosaurus:

	In.	Lin.
Length of the body of the third vertebra	2	0
Breadth of its articular end	2	0
Breadth of its middle part	1	4
Breadth of its inferior groove	0	4
Length of the transverse process	1	10
Antero-posterior diameter of the middle of process	0	4
Vertical diameter of base of process	1	6
Vertical diameter of expanded extremity	3	0
From the lower part of centrum to the origin of the spinous process	2	6

The spines appear to be anchylosed into a continuous ridge. The anterior surface

of the transverse process appears undulated by wide shallow depressions and intervening elevations.

The authors of a paper in the 'Philosophical Transactions' for 1849, who preceded me in the publication of the figures of the sacrum of the Iguanodon, first discovered by me in the collection of the late Mr. Saull, and described in my 'Report on British Fossil Reptiles,'* state that "the sacral fragment referred to the Hylæosaurus by Professor Owen cannot at present be found."

The fragment in question is the one above described. It has never, according to my observation, been absent from its place in the Hylæosaurian series of the British Museum, where it still bears the ticket and numbers, $\frac{484}{2484}$, under which its nature was first made known.†

In the paper in the 'Phil. Trans.,' above cited, the four confluent sacral vertebræ (Pl. 36) are figured as "belonging either to the Hylæosaurus or Iguanodon" (p. 301). The apparent inability to recognise the specimen of Hylæosaurian sacrum, No. 2484, by comparison with which the sacrum (Pl. 36) might have been determined, left the authors in the above state of doubt; yet the unequivocal Iguanodon's sacrum in Mr. Saull's museum suffices to differentiate the present specimen. It consists of the confluent bodies of four sacral vertebræ, answering to those marked *s* 2, *s* 3, *s* 4, and *s* 5, in Pls. 8—11 of the description of the Iguanodon (pp. 282—288).

The body of the second sacral vertebræ of the Hylæosaurus (Pl. 36, fig. 2, 2) is carinate below, as in the Iguanodon. Above it is smoothly excavated to form the floor of a capacious neural canal (fig. 1, *n*), whence the nerves escaped, passing over the centrum, in consequence of the blocking up of the vertebral interspace by the articulation there of the shifted neural arch.

The third sacral vertebra (3) is not carinate below, as in the Iguanodon, but grooved along the middle line, and the increase of breadth is relatively greater in the centrum.

This increase is still more marked in the fourth sacral vertebra (fig. 4), which is also longitudinally, but more widely, channelled along its under surface.

The breadth, as compared with the length, increases in the fifth sacral vertebra (5), shown to be the last, as in the Iguanodon, by the terminal articular surface for the first caudal vertebra. Like the preceding centrums, that of the fifth sacral vertebra in the Hylæosaurus is relatively broader and flatter below than in the Iguanodon: but the lateral compression beneath the wide outlets for the nerves, usually intervertebral in position in other reptiles, is well marked. These outlets are relatively wider in the Hylæosaurus than in the Iguanodon, and probably indicate greater activity, and a swifter rate of motion, in the smaller herbivorous Dinosaur.

The base of the pleurapophysis or rib-element—taking the place and function of

* 'Reports of the British Association,' volume of 1842, pp. 129—131. † Ib., pp. 113, 114.

an inferior transverse process in the Dinosaurian sacrum—may be discerned, wedged into the interspace between the second and third sacral vertebræ at *pl* 3, and again between the third and fourth vertebræ, at *pl* 4, fig. 2, Pl. 36.

A third portion of the sacrum of the Hylæosaurus, which escaped the cognizance of the authors of the paper in the 'Philosophical Transactions' for 1849, is the specimen No. 28,936, British Museum, Pl. 37, figs. 2, 3, 4. This consists of the third sacral vertebra, with part of the second and fourth anchylosed therewith, a great proportion of the neural arch, and a small part of the left ilium being included in this very instructive specimen. It is from the submerged Wealden of the Isle of Wight, and has been subject, like many of the fossils from that locality, to a certain degree of attrition by sea-waves on the beach.

The pleurapophysis (fig. 3, *pl* 3), continued from the obliterated interspace between the third and second vertebræ, quickly assumes the form of a broad and high plate, compressed from before backwards, and again becoming thickened when it abuts against the ilium (62).

The diapophysis (fig. 4, *d* 3), arising from the side of the neural arch, seems to form the upper part of the same broad, vertical, transverse wall of bone; but the suture between the pleurapophysial and diapophysial elements of this wall is clearly traceable, extending from the base of the neurapophysis upwards and outwards. The diapophysis at its upper part expands, and seems to bifurcate or abut against the side of the base of the neural spine. This spine forms, at the part of the sacrum here described, a continuous ridge of bone.

The fractured outer border of the ilium has been rounded and water-worn to its present form, which must not be taken as indicating its natural one. A large vacuity was bounded by the ilium and the two contiguous diapophysial plates (fig. 3), as in the sacrum of the Iguanodon: the large nerve-outlet, formed by the receding borders of contiguous neural arches, and the middle part of the centrum, opens into the large space above defined.

Caudal Vertebræ. Pl. 41.

A proportion of the tail, to the extent of nearly six feet, and including about twenty-six vertebræ, discovered in a quarry in Tilgate Forest in the year 1837, is preserved in the British Museum (Pl. 41). The diapophyses (*d*, *d*) present almost Crocodilian proportions, in regard to their length, at the interior part of this series, and may be discerned, though diminished to mere rudiments, in the small terminal vertebræ of the series. In the most perfect of the anterior vertebræ they are compressed vertically, but with convex, not flattened sides, and rounded edges, presenting

an elliptical transverse section, and preserving the same breadth to their truncated extremity: they extend outwards, and are slightly bent forwards: the breadth of this vertebra between the extremities of the transverse processes is 11 inches. The neurapophysis is curved forwards from the base of the diapophysis to form the prezygapophysis, or anterior oblique process: its length from the extremity of this process to that of the posterior one is $3\frac{1}{2}$ inches. The neurapophysis presents a simple convex external surface up to the base of the neural spine; the antero-posterior extent of this process is 2 inches. The hæmal arches are from 4 to 5 inches in length near the base of the tail (figs. 3 and 3*); they may be distinguished, like the diapophyses, by their convex external surface; their bases come into contact, as shown in fig. 3*, but are not confluent as in the Iguanodon; they articulate to two separate hypapophyses. Between the pairs of these tubercles, which are placed at each end of the under surface of the centrum, there is a longitudinal sulcus. The diapophyses soon lose the slight anterior curve, stand straight out, decrease in length, and descend from the neurapophysis to the centrum as the vertebræ approach the end of the tail.

The hæmal arches also decrease in length, but they expand in the antero-posterior direction at their unattached and dependent extremity, which is defined by a slight convex outline. Fig. 4 shows the modification of the under surface of the caudal vertebræ, at the middle of the tail; and fig. 5 gives a side view of one of the hæmal arches from this part, of the natural size. The following admeasurements give the rate of decrease in length in the caudal vertebræ, taken at intervals of six joints:

	In.	Lin.
Length of body of presumed 8th caudal	2	6
Length of body of presumed 14th caudal	2	4
Length of body of presumed 20th caudal	2	2

The sides of the slender posterior vertebræ are distinguished by a slight median expansion below the base of the rudimental transverse process, so that the surface, instead of being gently concave lengthwise, undulates by virtue of the middle elevation. I have not met with this character in the corresponding vertebræ of other Saurians. In the vertical direction the sides of the centrum in the posterior caudals converge at almost a right angle to the inferior groove. The greater breadth of the centrum, in proportion to its height, may still be discerned in the terminal caudal vertebræ (fig. 6): thus in the centrum 2 inches 2 lines long, the breadth was 1 inch 10 lines, and the height only 1 inch 3 lines. Here the bases of the short, but fore-and-aft extended, hæmapophyses appear to be confluent, as in fig. 7; but their peculiar shape would serve to distinguish them from a hæmal arch of an Iguanodon.

* 'Report on British Fossil Reptiles,' 1841, p. 114.

Bones of the Extremities.—Scapular arch.

The scapula of the Hylæosaurus (Pl. 35, 51, and Pl. 6) is longer and narrower than in the Monitors and Iguanas, adhering in this respect to the Crocodilian type, but most resembling in the shape of its blade or body, that of the genus Scincus. It differs, however, from the scapulæ of all known reptiles, and indicates an approach to the Mammalian type, by the production of a strong obtuse acromial ridge, separated by a deep and wide groove from the humeral and coracoid articular surfaces. The blade of the scapula is long, flattened, slightly convex on the inner and proportionally concave on the outer surface: the anterior margin is convex, the posterior one concave; the upper extremity or base truncate, slightly convex, with the posterior angle a little produced, the anterior angle rounded off. On the outer side of the scapula two broad convex ridges descend and converge to form the beginning of a thick and strong spine, at fourteen inches distance from the base; this then expands into the thick acromial ridge, which extends transversely, and is continued forwards as a long subprismatic process from the anterior angle of the head of the scapula. This process, the homologue of which exists in the scapula of the Iguanodon, and more developed in that of the Megalosaurus, is broken off in the present specimen about four inches from the neck of the scapula, with which it forms a right angle. The acromion is perforated at the base of its anterior prolongation by a foramen analogous to the supraspinal one in the scapula of the Edentate Mammalia. Besides the scapulæ preserved in the connected part of the skeleton, there is, in the Mantellian Museum, a nearly entire and detached scapula of larger size, discovered, in connection with many other bones of the skeleton, in a layer of blue clay near Bolney, in Sussex, and indicating the connected part of the skeleton first discovered in 1832 to have belonged to an immature individual. The dimensions of this scapula are as follows:

	In.	Lin.
Length of the scapula	18	0
Breadth of its base	8	0
Breadth of its neck	3	9
Thickness of its base	1	0
Thickness of its neck	2	6
Breadth of subacromial groove	2	0
Breadth of humeral articulation	4	0
Breadth of coracoid articulation	2	6

The coracoids, Pl. 35, 52, present a much more simple form than in the Megalosaurus, and resemble those of the Scink and Chameleon, thus deviating in their great breadth, like the coracoids of the Enaliosaurs, from the Crocodilian type. In the

portion of the skeleton the right coracoid is slightly bent out of place and thrust under the left one; and there is no trace of a sternal or entosternal bone in their interspace. The median margin of the coracoid describes an uninterrupted and full convex curve commencing at the angle dividing it from the scapular articular surface; but it is separated by a concavity or emargination from the articular surface for the humerus. It is perforated by a moderate-sized elliptical canal, about two inches from the humeral articulation, and in this respect resembles the same bone in the Iguana, Monitors, and Lizards, and differs from that in the Scinks and Chameleons. The antero-posterior extent of the coracoid in the connected portion of the skeleton, Pl. 35, is 8 inches; its transverse diameter 5 inches.

Tibia of the Hylæosaurus. Pl. 38.

One of the long bones of a limb, with a phalangeal bone, and a scapula, of the Hylæosaurus, were discovered in a quarry of Wealden stone at Bolney, in Sussex.

The long-bone is figured by Dr. Mantell as a humerus.* It bears a much closer resemblance to the tibia of the Megalosaurus,† but it is shorter and more expanded at its distal end in proportion to its length.

The proximal end (Pl. 38, fig. 3), which is $6\frac{1}{2}$ inches by $3\frac{1}{2}$ inches in its long and short diameters, shows a median tuberosity (*a*), divided by a depression from a second smaller tuberosity (*b*) (this has been crushed in the specimen), which have articulated with the condyles of the femur. Anterior and external to these the proximal end of the bone is produced into a strong "procnemial" ridge (*c*), the front surface of which is roughened for the insertion of a strong ligament. The shaft of the bone rapidly contracts to a trihedral form, with the angles rounded off; then as rapidly expands, and becomes, as it were, flattened out; more especially by the production of the outer border (*f*), which shows a broad and shallow articular depression for the distal end of the fibula. The distal articular surface for the tarsus presents the same form of an oblique, wide, and shallow notch (*e*), as in the Megalosaurus.

The largest diameter of this end of the bone is 7 inches; the circumference of the middle of the shaft is 7 inches. At the back part of the shaft, five inches from the proximal end, is the orifice of a canal for the medullary artery, which passes obliquely downwards. The entire length of the bone is 16 inches.

Metapodium of the Hylæosaurus. Pl. 42.

The specimen, No. 2556, in the British Museum, figured in Pl. 42, exhibits three metacarpal or metatarsal bones of the same foot, cemented, as naturally connected, by

* 'Philosophical Transactions,' part ii, 1841.

† P. 346, Pl. 31.

the Wealden matrix. The shape of the outer (IV) and inner (II) of these bones indicates that three alone constituted their segment of the foot, unless some styliform rudiment may have existed, which has left no mark of junction with the next fully developed metapodial* bone.

Those bones of the foot of the Iguanodon, described in pp. 373—378, and figured in Pls. 43 and 44, afford a means of comparison with the present specimen, and show that it cannot belong to the corresponding foot of the Iguanodon, and that it is very improbable that it can belong to another (fore or hind) foot of the same species. It plainly indicates a foot of longer and more slender proportions, with a different configuration of the metapodial bones. The relative lengths of these bones show that they belong to a foot of the same side of the body as that of the Iguanodon above described.

The proximal ends of the three bones have been broken off obliquely, the outermost (Pl. 42, II) retaining the greatest proportion of the shaft: the innermost (ib., IV) retains its distal articular surface; the middle bone (ib., III) has a portion of the same surface. The distal end of the outermost bone is broken away.

By the analogy of the metapodium of the Iguanodon, the innermost metapodial of the present specimen answers to the second in the pentadactyle foot, the middle to the third, and the outermost to the fourth. The foot to which they belonged was functionally tridactyle, through the arrest of development or suppression of the first and fifth toes in the pentadactyle foot.

The metapodial (II) has a sub-compressed shaft, convex on the inner or free side (figs. 1 and 2), slightly concave towards the middle metapodial; with the anterior margin sharp, but not produced at the middle of the bone, as in the Iguanodon: the distal articular surface is convex at its anterior half, trochlear at its posterior half, or with a median, rather oblique groove between two tuberosities.

The middle metapodial (III) differs from that of the Iguanodon in its uniformly almost flat anterior surface. The outer metapodial (figs. 1 and 3, IV) has a flatter and relatively broader outer surface than in the Iguanodon: the antero-internal border subsides about half way down the shaft: the internal border appears to be produced towards the middle metapodial, as in the Iguanodon. The distal end of the outer metapodial (IV) must have extended lower than that of the inner one.

The size and texture of the above-described bones of the foot accord best with the characters of the osseous texture in the Hylæosaurus, of which they are probably part of the hind-foot.

* The term "metapodium" signifies the same segment in both fore- and hind-feet, and is requisite in treating of such segment when it cannot be determined whether it is of the fore-foot (metacarpus), or of the hind-foot (metatarsus).

Jaw of the Hylæosaurus? (Pl. 39, figs. 1—5).

No. $\frac{422}{2422}$, in the Reptilian Series of the British Museum, is a portion of the right ramus of the lower jaw, with characters distinguishing it from that of any other known Saurian: as, for example, its curvature, indicating the lower jaw to have been bent down in an unusual degree, and the remarkable inequality of its external surface. This fragment is about 3 inches long, 1 inch 7 lines deep at the hind part, and 1 inch 5 lines deep at the fore part; flattened and smooth at the inner side (Pl. 39, fig. 2), but having the outer side (fig. 1) raised by the termination of a strong angular ridge at its lower and hinder part, and by a rough convex longitudinal ridge extending along its upper part; the surface of the jaw being concave above and below this ridge. The lower margin is thick and convex; the upper one (fig. 3) is formed by a regular series of pretty close-set sockets, with the internal alveolar wall imperfectly developed, and in part broken away, displaying their partitions; but with the outer wall entire, thin, and slightly crenate at its upper margin (fig. 1).

At the hind part of this fragment (fig. 4) the anterior extremity of the splenial piece is preserved; the rest is formed exclusively by the dentary piece: the area of the wide conical cavity in the interior of the jaw is exposed at the back part of the fragment; its apical termination is near the fore part (fig. 5). A succession of large vascular canals open obliquely forwards in the concavity above the upper oblique longitudinal ridge. The whole of the outer surface is minutely ridged and punctate.

The depth of the sockets bears a smaller proportion to that of the jaw than in modern Lacertians or Crocodiles, being about one fourth of that depth (fig. 2); the partitions of the sockets, which are very regular in their breadth and depth, though they are more prominent than in the pleurodont Lizards, yet exhibit a fractured margin; there is no trace of a smooth natural surface of the bone in the interspace of the sockets; and at the part where the inner wall has been least mutilated, it nearly completes the socket, and incloses the long and slender fang of the tooth. Whence, I conclude, that the entire jaw of the extinct reptile would have exhibited a series of true sockets, with oblique outlets, not depressions merely, as in the present mutilated fragment; and that it would have agreed with the Megalosaurus in presenting the sub-thecodont mode of implantation of the teeth.

The crowns of all the teeth are broken off; the small sockets of reserve, exposed at the inner side of the base of the old sockets, do not contain any evidence of the species to which this fossil has belonged.

In my 'Odontography,'* I adopted the opinion of Dr. Mantell† respecting the present fossil, viz., that it belonged to a young Iguanodon; but subsequent considerations‡ induced me to refer it to the same species of extinct reptile as the teeth (Pl. 39, figs. 6—9) belonged to.

Since the publication of my 'Reports on British Fossil Reptiles,' the lower jaw of the Iguanodon has been discovered, and leaves no room for doubt as to the generic and specific distinction of the present fossil. In the portion of jaw in question (Pl. 39, figs. 2 and 3) there are eighteen alveoli in an extent of three inches: in the lower jaw of a young Iguanodon of the same size, there are but nine alveoli in the same longitudinal extent; whilst in three inches of the dentary border of the mandible of an older Iguanodon, there are but four alveoli. The form of the alveoli, as I had inferred from the known shape of the teeth of the Iguanodon, differs from that of the alveoli in the portion of jaw figured in Pl. 39; but those alveoli accord with the shape of the fangs of the teeth next to be described.

Teeth of the Hylæosaur? Pl. 39, figs. 6—9.

At the period of preparing my 'Report on British Fossil Reptiles,' the teeth of the Hylæosaurus were unknown; but in the quarries where the bones of that reptile had been discovered, a few teeth had been met with of a peculiar form, respecting which Dr. Mantell wrote—"They appear to have belonged to a reptile, and are entirely distinct from those of the Megalosaurus, Iguanodon, Crocodile, and Plesiosaurus, whose remains occur in the Tilgate strata."§ The form and structure of these teeth (Pl. 39,

* Part II, 1839, p. 248. † 'Wonders of Geology,' vol. i, p. 393.

‡ "In the absence of this characteristic part of the tooth, an element in guiding our choice between the Iguanodon and Hylæosaur is given by the breadth of the interspaces of the sockets; these must bear relation to the breadth of the crowns of the teeth, if we suppose that they were in contact throughout the series, as in Lacertians. Now, the teeth of the Iguanodon, and those which I have referred to the Hylæosaur, differ in a marked degree in the breadth of the crown. The complicated and expanded crown of the Iguanodon's tooth is supported on a narrower stem; and the stems or fangs, if the crowns were in contact without overlapping, must have been separated by interspaces of proportional breadth, viz., twice their own breadth; but the thickness of the crown of the tooth of the Iguanodon renders it very unlikely that they did overlap each other. Now, the crowns of the teeth of the Hylæosaur are expanded to such an extent as, if in contact, to require an interspace of the fangs, not broader than the fangs themselves; and the interspaces of the fangs in the fragment of jaw under consideration correspond with crowns of this breadth. The fangs of the teeth in the Iguanodon are conical, and more or less angular; in the teeth presumed to belong to the Hylæosaur the fangs are cylindrical; the sockets in the present fragment correspond with the latter form." (Report on British Fossil Reptilia, in the 'Reports of British Association,' 1841, p. 110.)

§ 'Wonders of Geology,' vol. i, p. 403.

figs. 6, 7, and 8) deviate too much from those of the Crocodilian family to make at all probable a reference of them to the genera Poikilopleuron, Streptospondylus, or Cetiosaurus, which are much more closely allied to the Crocodilians than is the Hylæosaurus. In a later work,* Dr. Mantell attributes these teeth, on the authority of M. Boué, to the Cylindricodon, a name by which Dr. Jäger distinguishes one of the species of his genus "Phytosaurus." I have been favoured by Dr. Jäger with one of the bodies supposed to be the teeth of the Cylindricodon of the Wirtemberg Keuper, but it is merely the cast of a cylindrical cavity, consisting entirely of that mineral substance, without a trace of dental structure. The difference of form between the Wealden teeth now under consideration, and those on which the *Phytosaurus cylindricodon* of Jäger was founded, is pointed out in detail in my 'Odontography,'† and has been likewise appreciated by the estimable palæontologist, M. Fischer de Waldheim, by whom their resemblance to certain Saurian teeth from the Ural Mountains, belonging to the genus Rhopalodon, is indicated. From these teeth, however, the presumed Hylæosaurian teeth differ in having thick and flat instead of serrated coronal margins.

The fang of the tooth is subcylindrical, subelongate, smooth; as it approaches the crown it diminishes in one diameter, and slightly and gradually expands in the opposite diameter, forming a sub-compressed, slightly incurved crown, with the borders straight and converging at a moderately acute angle to the apex. These borders, in most specimens, are more or less worn, indicating the teeth of the opposite jaws to have been placed alternately, so as to meet and reciprocally occupy the angular vacuities left by the sloping borders of the crown: the enamel at these borders being worn away, and the dentine exposed.

The following is the result of a microscopical examination of these teeth. The tooth consists of a body of dentine covered by a thick coating of clear enamel, with minute superficial longitudinal striæ, and surrounding a small central column of osteodentine, consisting of the calcified remains of the pulp. The dentine differs, like that of existing Lacertians, from the dentine of the Iguanodon in the entire absence of the numerous medullary canals which form so striking a characteristic of the more gigantic Wealden reptile. The main dentinal tubes are characterised by the slight degree of their primary inflections; they are continued in an unusually direct course from the pulp-cavity to the outer surface of the dentine, at nearly right angles with that surface, but slightly inclined towards the expanded summit of the tooth. They are chiefly remarkable for the large relative size of their secondary branches, which diverge from the trunks in irregular and broken curves, the concavity being always towards the pulp-cavity. In most parts of the tooth, the number of these branches obscures even the thinnest sections.

* 'Geology of the South-east of England,' p. 293.

† P. 196.

The ossified pulp exhibits the parallel concentric layers of the ossified matter surrounding slender medullary canals, and interspersed with irregular elliptical radiated cells, affording the usual characters of the texture of the bone in the higher reptiles.

From the form and structure of these teeth, it may be inferred that they have belonged to a Dinosaurian reptile; not so strictly phytiphagous as in the Iguanodon, but probably having a mixed diet.

In reference to the size of both the fragment of jaw and of the teeth, there is about the same proportion between them and the known remains of the Hylæosaurus, as between the jaw with teeth of the Iguanodon and the vertebræ and limb-bones of that colossal Dinosaur. The structure of the osseous substance of the portion of jaw figured in Pl. 39, closely accords with that of the known bones of the Hylæosaurus.

Having, therefore, demonstrated that the above-described mandibular and dental fossils of the Wealden do not appertain to the Iguanodon, nor to the Cylindricodon, it has appeared to me more to the interests of palæontology to refrain from adding to its catalogues a new name, which at present could signify nothing but the bare possibility that the grounds for approximating the fossils in question to the Hylæosaurus may prove not to be valid.

Dermal Scutes.

Unequivocal evidence that a dermal skeleton, analogous to that in the recent Crocodiles, was developed in the Hylæosaurus, has been afforded by the discovery of bony scutes in the mass of petrified vegetable matter removed in clearing the portion of the skeleton first described. Some of these detached bony plates still adhere to the caudal vertebræ, and may be observed to decrease in size as they approach the end of the tail (Pl. 41, fig. 1, *i*, *i*). From their form, which is elliptical or circular, and from the absence of any surface indicating the overlapping of an adjoining scute, it may be inferred that the bony plates in question studded in an unconnected order the skin of the Hylæosaur. The diameter of the largest of these scutes does not exceed 3 inches; the smallest present a diameter of 1 inch. They are flat on the under surface, convex with the summit developed into a tubercle in the smaller specimens, but which is less prominent in the larger ones: the outer surface is studded all over by very small tubercles: the inner surface presents the fine decussating straight lines, which I have described as characterising that surface, in the scutes of the Goniopholis.*

By the kindness of Dr. Mantell, I was favoured, when preparing my 'Report on

* 'Reports of British Association,' 1841, p. 71.

Fossil Reptiles,' in 1840, with the means of submitting the structure of a dermal scute of the Hylæosaur to microscopical examination. This structure is represented in Pl. 40, fig. 1, and was described in my 'Report' as follows:

"The medullary canals, which are stained brown, as if with the hematosine of the old reptile, differ from those of ordinary bone in the paucity or absence of concentric layers. They are situated in the interspaces of straight, opaque, decussated filaments, which frequently seem to be cut short off close to the medullary canals. Very fine lines may be observed to radiate from some of the medullary canals: irregularly shaped, oblong, and angular radiated cells are scattered through most parts of the osseous tissue, but they present less uniformity of size than do the Purkinjian cells in ordinary bone. The most striking characteristics of the dermal bone are the long, straight, spicular fibres which traverse it, and decussate each other in all directions, representing, as it seems, the ossified ligamentous fibres of the original corium."*

Dermal Spines? Pls. 35 and 40.

On the left side of the thorax, partly overlying the left scapula and vertebral ribs in the large slab of stone containing the anterior part of the skeleton, now in the British Museum, there are some large elongated, flattened, pointed plates of bone, three of which seem to follow each other in natural succession (Pl. 35, *d, d, d*). The length of the first of these plates is 17 inches, the breadth of the base 5 inches, equal to the antero-posterior diameter of two vertebræ: they decrease somewhat rapidly in length, the second being 14 inches long, and the third 11 inches long; but they slightly increase in breadth.

These remarkable bones were regarded by Dr. Mantell† as having formed part of a serrated fringe extended along the back of the animal, analogous to that of the Cyclura Lizard. The chief objection, though not decisive, against this view is, a want of symmetry in the form of the most perfect of them. They are nearly flat, but along the middle present a slight degree of concavity towards the observer, which, however, I once thought "might be paralleled by a similar concavity on the oposite side buried in the stone;"‡ but a separate specimen since obtained proves that side to have been convex (Pl. 40, fig. 3); and the anterior margin in the bones (*d, d,* Pl. 35) inclines from the middle line towards the concave side.

With regard to their relative position to the rest of the skeleton, it must be remembered that the ventral surface of this is exposed (Pl. 35); so that the under

* Ib., p. 115.

† 'Geology of the South-east of England,' p. 323; 'Wonders of Geology,' vol. i, p402. .

‡ 'Reports of British Association,' 1841, p. 116.

parts of the bodies of the vertebræ are towards the observer, and their spines imbedded in the matrix. The coracoids (52) and scapulæ (51) are placed, as might be expected in a skeleton little disturbed and lying on its back, with their under surfaces towards the observer, and covering, like a buckler, a portion of the vertebræ and ribs. In this position we might look for a portion of the apparatus of the sternal or abdominal ribs, in the hope of discerning the modifications of these variable parts which might characterise a genus differing in many peculiarities from other known Saurians. Now it is with the apparatus of abdominal ribs, which present such a diversity of characters in other Saurians, that it may be useful to compare the long flattened bones in question, as well as with the supporting bones of a dorsal crest, in the event of a future discovery of a skeleton or portion of skeleton of the Hylæosaurus including these bones. The objection to their being abdominal ribs, which may be founded on their great relative breadth as compared with those ribs in other Saurians, and especially with the vertebral ribs of the Hylæosaurus itself, deserves due consideration; but the same objection applies to the bones in question as compared with the superadded spines in the Lizard with a dorsal fringe, or with the spines of the vertebræ themselves in the Hylæosaurus. For the dorsal dermal spines in the Cyclura correspond in number with the spines of the vertebræ which support them, while the base of each of the hypothetical dermal spines of the Hylæosaurus extends over more than two vertebræ.

In the Monotrematous quadrupeds (*Ornithorhynchus* and *Echidna*) the abdominal ribs are as much broader than the vertebral ribs as they would be in the Hylæosaurus, on the costal hypothesis of the detached bony plates here suggested; and, after the close repetition in the Ichthyosaurus, of another of the remarkable deviations in those aberrant Mammals from the osteological type of their class, viz., in the structure of their sternal and scapular arch, the reappearance of the monotrematous modification of the sternal ribs in the present extinct reptile would not be surprising. The want of symmetry and the difference of size and form, above alluded to, in the four succeeding spine-shaped plates, agree better with the costal than the spinous hypothesis.

Whether the bones in question be dorsal spines or abdominal ribs, they have evidently been displaced from their natural position in the partial disarticulation of the entire skeleton (Pl. 35) prior to its immersion in the mud that has been subsequently hardened around it; but the degree of displacement has not been greater in the one case than in the other.

In offering, with due diffidence, a choice of opinions respecting the nature of these singular bones, I have been actuated solely with the view of accelerating the acquisition of the true one; which, it is obvious, will be more likely to be attained by the choice being present to the mind of subsequent fortunate discoverers of these remains of the Hylæosaurus, than if they were solely preoccupied by the hypothesis of the dorsal fringe. For example, it may lead to more careful noting of the constancy or otherwise

of the unsymmetrical inclination of the convex margin of the spine, and whether they form, or are disposed in, pairs; which, on the costal hypothesis, may be expected, in the event of another skeleton being discovered.

The peculiarly unsymmetrical figure of these problematical bones is strikingly shown in the specimen (Pl. 40, figs. 2 and 3, No. 28,851, now in the British Museum) discovered in the same quarry in Tilgate Forest, whence the above-described part of the skeleton of the Hylæosaurus was obtained.

It is a long triangular plate of bone (fig. 3), thickened at the base, becoming rapidly compressed or flattened beyond it, and gradually decreasing in thickness and breadth to the apex. Both the apex and one angle of the base have been broken away; but the bone can hardly have been under 8 inches across the base, and 15 inches in total length.

The base is surrounded by a low, obtuse, thick ridge (*a*), and is excavated by an irregular angular depression (*b*), the sides of which extend below or beyond the boundary ridge, at *c* and *d*; these productions not being opposite, but adding to the general oblique and unsymmetrical character of the apparently articular surface.

The body of the bone is moderately convex on one side (Pl. 40, fig. 3), and correspondingly concave on the opposite side, at the basal two thirds of its extent, beyond which the surface becomes convex transversely, but retaining its longitudinal concavity (fig. 2).

Several coarse vascular canals open upon and groove for a greater or less extent the outer surface of the bone, indicative of the periosteum being connected with a corium producing a thick epidermal covering; and this feature much inclines me to regard the bone as a true dermal spine. On the same hypothesis, the groove between the boundary ridge of the base and the projecting parts of the border of the basal depression, may have served for the implantation of dermal muscles, regulating the position of such spine.

But if these osteodermal spines formed a single series along the mid-ridge of the back, as the purely epidermal spines do in the Cyclura, they must have overlapped each other, and the unsymmetrical form must have related to such unusual disposition. In the *Xiphosurus velifer* of Cuvier, the fin-like crest along the dorsal aspect of the tail is supported by osseous spines: in the *Lophura* a dorsal crest is similarly supported; but the dermal spines are symmetrical. There remains the hypothesis, that there may have been two series of such spines, projecting one from each side of the dorsal region of the Hylæosaurus.

The shortness of the tibia, and the unusual development of its terminal processes for muscular attachments, indicate great strength of the hind limbs; and the glimpses which we thus obtain of this Wealden Dinosaur suggest most strange ideas of its form and habits.

The remains of *Hylæosaurus armatus* have been discovered in the Wealden formation at Battle, Bolney, and Tilgate Forest, Sussex.

IGUANODON.

Supplement No. 1.

Restoration of the (Hind?) Foot. Plates 43 and 44.

In a former part of the present history * the characteristic form of certain toe-phalanges was described; such phalanges, at least, were inferred to belong to the Iguanodon, with a high degree of probability, on evidence of association with other undoubted parts of the skeleton of that reptile, and more especially in the instance of the Maidstone skeleton;† but at that period the exact structure and number of toes of either fore or hind foot were unknown.

On the basis, however, of the determination of detached phalangeal bones in pp. 316—318, the present restoration of an entire—probably hind—foot, the carpus or tarsus excepted, of the Iguanodon, has been carried out; the ungual phalanges in the series of bones of this foot (Pls. 43 and 44) closely corresponding in shape with the depressed and obtuse phalanges referred to that extinct animal in the above-cited pages and plates. This most interesting and instructive framework of the foot of the great Dinosaurian herbivorous reptile was, moreover, found in a formation and at a locality where unequivocal vertebræ and other parts of the Iguanodon are common; so that I feel great confidence in the correctness of the present contribution towards a complete reconstruction of the Iguanodon.

The discovery and acquisition of the unique specimen, figured in Pls. 43 and 44, are due to S. H. Beckles, Esq., F.G.S., the author of the papers on the 'Ornithöidichnites of the Wealden,'‡ and who first definitely called the attention of geologists to the singular "trifid," or tridactyle impressions in the Wealden of Sussex, of which he was the chief discoverer, and has been the most persevering investigator.

It seems a peculiarly appropriate reward for these researches, that the acquisition of the fossils demonstrating the tridactyle structure of one of the feet of the Iguanodon should have been reserved for Mr. Beckles. These fossils, moreover, were not fortuitously acquired, but were the fruit of special researches, assiduously carried on by Mr. Beckles on the south-west coast of the Isle of Wight, with a view to materials for completing our knowledge of the great Wealden reptiles.

Between Brook and Brixton, in the submerged Wealden bed, near low-water mark, indications of the entire skeleton of a young, perhaps half-grown, Iguanodon were detected. The bones of the foot which were most within reach had been very little

* Section iii, Ch. i, p. 316, Pls. 21 and 22. † pp. 259, *Dinosauria*, Pls. 1 and 2.

‡ 'Quarterly Journal of the Geological Society,' January, 1851, and November, 1852.

disturbed. The metatarsus (Pl. 43, ii, iii, iv) was extracted in one piece; the phalanges of an outer toe (ib., 1 IV—5 IV) were extracted in a second piece: they had been somewhat distorted at the time of imbedding, for the matrix had hardened around, and preserved them in that state. The phalanges of the toe of the opposite side of the foot (ib., 1 II—3 II) were extracted similarly cemented together by the matrix, but in their natural juxtaposition. Three of the phalanges of the middle toe (ib., 1 III—3 III) were also joined together by the matrix; the fourth, or ungual phalanx of this toe, was extracted separately; but Mr. Beckles's attention having been, unluckily, diverted to another subject at this time, the fossil got into the hands of an idle looker-on, who cast it into the sea. All the other bones of the foot Mr. Beckles caused to be carefully packed, and transmitted to me for description.

I employed a skilful lapidary to clear away the adherent matrix, and to separate the cemented phalanges of the distorted toe, for the examination of their articular surfaces, and the result of my comparisons were communicated briefly to the Geological Society of London, on the occasion of exhibiting the specimen at the meeting held June 17th, 1857.

As has already been stated, the bones, whether carpal or tarsal, which unite the foot proper to the limb, are wanting. The metapodium,* fortunately, yields the required proof of the precise number of toes.

As a general rule, only the metapodials which bound or form the outer and the inner sides of that segment of the foot have the proximo-lateral articular surface confined to one side of the bone; the intermediate metapodials show such surface on both sides, for articulation with the contiguous metapodials. The metapodial (Pls. 43 and 44, IV), which will presently be shown to be the outermost, had its outer side rounded, and simply roughened for the implantation of ligamentous fibres; the metapodial on the opposite side (ib., II) also presented a convexity toward that border of the foot; but a small part of the middle of that convexity is articulated with a slender rudiment of a metapodial (ib., I), which forms the real boundary of that—the inner side of the foot. The upper portion of this metapodial, which resembles the "splint-bone" in the metapodium of the horse, has been fractured and partially dislocated before the induration of the matrix; the lower portion of the bone is in its natural position, and seems to have been anchylosed with the contiguous fully developed metapodium: the extremity of this lower portion, however, is broken away; so that, whether it ended in a point, like the rudimental metapodials in the horse, or supported a diminutive toe, like the metapodials of the spurious hoofs in the ox and musk-deer, cannot be at present determined.

* I use this word to signify the same segment in both fore- and hind-limbs: "metacarpus" is the specific term for the segment in the fore-limb; "metatarsus" for that in the hind-limb. But, in the gradual reconstruction of the skeleton of a strange reptile, it is requisite to have a term expressive of the more general kind of knowledge at first acquired. Metapodial is equivalent to metacarpal or metatarsal.

As the fully developed toes which follow this rudiment have respectively three, four, and five phalanges, the analogy of both the fore- and hind-foot of the Iguanas and Monitors would indicate the small innermost metapodial (Pls. 43 and 44, I) to be the rudiment of the first toe (pollex or hallux), and the three fully developed toes to be the homologues of the second, third, and fourth toes of the feet in the Lizard tribe; the fifth toe being wholly suppressed in the Iguanodon. The analogy of the Crocodilian foot would lead to the same conclusion, since the second toe in that reptile has three phalanges, and the third toe has four phalanges, whilst in the hind-foot the fifth toe is suppressed. The fourth toe, however, in some of the *Crocodilia* differs from that in the *Lacertilia*, in having only four phalanges, and usually wanting a claw. Hence it would seem that, whilst the Iguanodon resembled the *Crocodilia*, as regards the hind-foot in that order, in the suppression of the fifth toe, it resembled the *Lacertilia* in having the fourth toe unguiculate, and with five phalanges: but it differs from both those Reptilian orders in the suppression of the first toe, and its representation by a hidden rudimental metatarsal, thus reducing the number of conspicuous and functional toes to "three."

The resemblance to the hind-foot of the *Crocodilia* in the suppression of the fifth toe, and the resemblance of the third and fourth toes, in regard to their nearly equal length, to those toes in the Monitor, render it most probable that the tridactyle foot of the Iguanodon, here described, is a "hind-foot;" but it cannot be assumed that the fore-foot may not have been similarly modified.

In the leading characteristics of the bony framework of the foot, whether fore or hind, it is interesting to find that the Iguanodon manifests a combination of Crocodilian and Lacertian characters, with superinduced Dinosaurian peculiarities, analogous to the plan of structure which I have had occasion to point out in other parts of its fossilized remains. So far as the Dinosaurian peculiarity of a reduced number of functional toes prevails, that order departs further from the general Reptilian type than do the existing Crocodiles and Lizards.

Having premised these general remarks on the fossils in question, I proceed next to point out the chief characters of the constituent bones of the foot.

The rudimental metapodial of the first or innermost toe (Pls. 43 and 44, I) articulates by its proximal end with a notch, 9 lines in diameter, at the middle of the inner (tibial) surface of the second metapodial (II). It seems not to have been anchylosed at this part, from the circumstance that the slender bone has been broken, soon after death or interment, and the upper portion has been displaced obliquely from the lower half, which maintains, perhaps through anchylosis, its natural position; the displaced portion is cemented in that position by the hardened matrix to the contiguous large metapodial.* The rudimental metapodial, 9 lines by 6 lines in the

* In the figure it is represented as restored to its natural position.

two diameters of its proximal end, gradually becomes more slender as it descends; its lower half is trihedral, and stands rather sharply out from the large metapodial (II); its extremity is broken off; the large and small diameters of the lower fractured end are 5 lines and 3 lines. It is not probable that its presence was conspicuous beneath the integument which covered it, but it may have supported a rudimental toe and claw.

The second metapodial (ib., II) is 8 inches in length, $4\frac{1}{2}$ inches in the longest diameter of the proximal end, 3 inches in that of the distal end. The bone expands at both ends, more suddenly at the distal one; it is convex on its free or tibial side, flattened on the side next the third metapodial, with the anterior border produced near the middle of the shaft into a process with a convex outline, and with a ridge projecting from the inner and back part of the proximal end. This ridge has been fractured. The outer or fibular angle of the back part of the proximal end is produced towards the next large metapodial, but has likewise been fractured. The articular surface at this end is flat, rather rough, showing vascular pits and other evidence of having been covered, in the recent state, by a layer of fibro-cartilage: by which it was articulated to the innermost tarsal or carpal bone. The distal articular surface is convex from before backwards, slightly convex transversely at its anterior half, with a middle concavity and lateral convexities, transversely, at the posterior half, which is somewhat broader than the fore part of the joint, and with the outer (fibular) angle produced.

The inner (tibial) side of the distal end of this metapodial has a broad and shallow depression for the attachment of a lateral ligament; the articular surface is two inches and a half higher than that of the adjoining (third) metapodial, and the proximal end is one inch and a half higher than that of the adjoining bone; but this is probably due to some dislocation of the metapodial before the matrix hardened around it.

The third metapodial (ib., III) is $11\frac{1}{2}$ inches in length. The proximal articular surface is slightly convex; a small portion of its back part is continued upon a thick process from that part of the bone, which rises some way above the level of the horizontal surface, apparently about an inch; but the summit of this process has been broken off. This process subsides as it descends to the inner border of the shaft, about halfway down.

The inner and anterior angle of the proximal end is produced toward the second metapodial, rendering the side next that bone rather hollowed out, as for its reception when in its proper position. There is no process from the middle of the shaft near its fore part, as in the second metapodial. The distal end expands into a broad trochlear surface, convex from before backwards, concave transversely; the fore-and-aft extent of the tibial side of this joint is the greatest; it appears to have been covered by articular cartilage, the extent of the cartilage being well defined by the transverse line at which the smooth surface rises a little above the level of the rough surface for ligamentous attachment.

The fourth metapodial (Pls. 43 and 44, IV), which is here the third fully developed, and at the same time the outermost one, is 9 inches in length. Its proximal end is of a semi-elliptical form, concave towards the middle metatarsal, to which it articulates in the present specimen two inches below the proximal end of that bone; but there may have been some displacement of the bone prior to fossilization. The inner and posterior angle of the upper part of the shaft of the fourth metatarsal is slightly produced, as is also the same angle of the shaft below its middle. The front surface of the shaft is smooth and convex; the back part is almost flat, and is crossed obliquely near its lower end by a rough ridge.

The distal articular surface (Pl. 44, fig. 3, IV) is oblique, but in the opposite direction to that of the second metapodial (II); the transverse concavity of the surface is slight, and is also limited to the hinder half; the anterior fibular angle is produced. The extent of the articular cartilage of the joint is indicated by the raised line, as in the middle metapodial; the concavity on the inner side of the distal end is deep and well defined.

The innermost of the three toes (Pl. 43 and 44, II 1, 2, 3), answering to the second in the hind-foot of the Iguana, includes three phalanges, and measures in total length 10 inches.

The first phalanx (II 1) is $4\frac{1}{2}$ inches in length; its proximal surface is obliquely sub-quadrate, very slightly concave, with the upper and outer (fibular) angle most produced, but rounded off; it is notched at the middle of the lower (plantar) border. Near this border, on the plantar aspect of the shaft, are two tuberosities for insertion of tendons. The distal articular surface is a trochlear one, convex vertically, and expanding as it descends; concave, but in a less degree, transversely; with the inner (tibial) side of greater extent. On both sides the articular border is slightly raised, forming the lower boundary of the wide concavity for the attachment of the lateral ligaments.

The second phalanx (II 2) is broader than it is long, its extreme breadth being 2 inches 4 lines. The proximal articular surface, with its concavity and convexity the reverse of those of the surface on which it plays, is triangular, with the angles largely rounded off. The under surface of this phalanx is somewhat flattened; the upper surface is contracted; the distal trochlea, very convex vertically, is flat transversely, at its upper half, slightly concave below; the modification resembling that of the phalanx supporting the unequal one in the other toes.

The third phalanx (II 3), which supported the claw, presents an oblique basal articular surface, flattened transversely and produced backwards above; slightly convex transversely below. The unequal part is sub-depressed, obtuse, obliquely bent downwards and outwards, but in a slight degree; the base of the bone is notched at each side, where the vascular canals relating to the growth of the claw commence; they impress the upper and lateral parts of the bone, which is $4\frac{1}{2}$ inches in length.

The proximal phalanx of the middle toe (Pl. 43 and 44, III 1), answering to the

third in the Iguana, shows its increase chiefly in breadth and thickness; its length is $4\frac{1}{2}$ inches. The proximal end, of a transversely oval form, is slightly and irregularly concave; its distal end is broader but less deep than that of the outer toe, and the shape of the trochlea is more symmetrical; the outer slightly exceeds the inner side in extent. The increase in the transverse over the longitudinal and vertical diameters is more marked in the second and third phalanges (III 2 and 3) of the middle toe; the latter phalanx shows the same flatness transversely, at the upper part of its distal trochlea, as in the corresponding phalanx of the outer toe. This structure indicates the next phalanx to have been an ungual one, resembling, as Mr. Beckles informed me, in its general character, the long terminal phalanx in the adjoining toes. It is indicated in outline in Pl. 43, 4 III.

All the five phalanges of the outer toe (IV 1, 2, 3, 4, 5) are preserved; the entire length of the toe is $8\frac{1}{2}$ inches, being rather shorter than the inner, but apparently longer from the lower position of the metapodial bone (IV). In this proportion the Iguanodon differed from existing Lizards, and resembled the Crocodiles.

The proximal phalanx of the outer toe (IV 1), answering to the fourth in the Iguana's foot, is 3 inches in length, with a subtrihedral body, one side turned to the next toe, and one angle inwards and downwards. The proximal surface is flat; the distal one trochlear, but with the transverse concavity less deep than in the first phalanx of the inner toe. The three succeeding phalanges (IV 2, 3, and 4) are similar in character, but progressively decrease in size; they are very short in comparison to their breadth.

The ungual phalanx (IV 5) is relatively more slender than in the inner toe: its length is 4 inches; its basal breadth 1 inch 10 lines. The obliquity of the bone is slight, and in the opposite direction to that of the inner toe.

Should any rudimental or spurious claw have been supported by the metapodial of the innermost digit (Pl. 44, fig. 1, I), the development of which toe is so remarkably arrested, it would probably present that form, and in regard to the fully grown Iguanodon, that size, which characterises the claw-phalanx which has been mistaken for the "horn" of the Iguanodon. It is probable that, in the fore-foot, the toe answering to the innermost in the Iguana's foot was better developed than its homotype in the hind-foot.

Not far from where the foot-bones were found, the femur, tibia, and fibula, of the same Iguanodon were extracted,—a circumstance which adds to the probability of their belonging to the same limb.

The modification of the present foot, whether of the fore- or hind-limb, of the Iguanodon is unique, according to present knowledge, in the class *Reptilia.* It exhibits an adaptation to terrestrial progression, and the support of a weighty superincumbent trunk, akin to that which we observe in the tridactyle foot of the heavy perissodactyle Pachyderms, represented at the present day by the Rhinoceros and Tapir.

Order—*PTEROSAURIA.*

SUPPLEMENT No. I.

PTERODACTYLES OF THE UPPER GREEN-SAND.

Genus—Pterodactylus, *Cuvier.*

In Chapter V, p. 257, of the present work, the occurrence of remains of a large Pterodactyle in the Green-sand formation near Cambridge, is noticed, and portions of the wing-bones are figured in Pl. 5, figs. 6—8 (*Pterosauria*).

Since that chapter was printed off, the Woodwardian Museum of the University of Cambridge has been enriched by successive acquisitions of fossils, obtained from the same stratum of 'Upper Green-sand,' near Cambridge. All those belonging to the *Pterosauria* have been liberally transmitted to me by my friend Professor Sedgwick for description and illustration in the 'History of British Fossil Reptiles,' and I have subsequently received a few highly interesting additional examples of Pterodactyle remains from sources which will be duly acknowledged in the sequel.

Pterodactylus Sedgwickii, *Owen.* Jaws and teeth, Pl. 7.

The specimen (Pl. 7, fig. 1, *a*, *b*, *c*, *d*) is the fore part of the upper jaw, containing the first seven sockets of the teeth, in a few of the anterior of which the base of the tooth is retained. The first two sockets open upon the obtuse extremity of the jaw (fig. 1, *c*), and have a direction showing that their teeth projected obliquely forward, so as to prolong the prehensile reach of the jaw; the second and third sockets are the largest, and cause a slight transverse swelling (fig. 1, *b*); the fourth is suddenly smaller, and the three following retain nearly the same size, or show a slight increase as they pass backward. The apertures of the sockets are elliptic, with the long axis extending obliquely from before outward and backward, not parallel with

the axis of the jaw; the plane of the outlet inclines slightly outward (fig. 1, *c*). The interval between two sockets is about half the long diameter of each. On one side of the figured specimen the fifth socket is obliterated. The anterior termination of the jaw is obtuse; the sides are smooth, flat, converging at an acute angle to what almost forms a ridge above (fig. 1, *c*, *d*); the jaw gradually increases in vertical diameter as it proceeds backward, the upper contour being straight as far as it can be traced in the fossil. The palatal surface is entire, narrowest between the second sockets, suddenly broader and flat between the third pair, retaining about the same breadth, but with a slight convexity and feeble indication of a median ridge in the rest of its extent, the ridge not being so strongly marked as it appears in fig. 1, *b*.

The Pterosaurian nature of this fossil is shown by the extreme thinness of the compact bony wall of the jaw; its relation to the genus *Pterodactylus*, as contradistinguished from the *Rhamphorhynchus*, V. Meyer, is proved by the terminal position of the sockets; and sufficient of the outer side wall of the jaw is preserved to show that the nostril did not advance so far forward as in *Dimorphodon*—the generic form of Pterodactyle from the Lower Lias.

By its size and proper Pterodactyle affinities the present specimen most resembles *Pterodactylus Cuvieri* of the Chalk, (p. 242, Pl. 3, figs. 1—7); but it offers the following well-marked differences: a greater proportional size of the anterior sockets, with a corresponding expansion of the fore part of the jaw; a greater number and closer arrangement of the sockets; a greater depth of the jaw, in proportion to the breadth of the palate. The extent of the jaw, *e. g.*, containing the first seven sockets, in *Pterodactylus Sedgwickii*, is 2 inches 9 lines; but in *Pterodactylus Cuvieri* it is 3 inches 6 lines: the depth of the jaw, above the third socket, in *Pter. Sedgwickii*, is 14 lines; in *Pter. Cuvieri* it is 8 lines; whilst the breadth of the palate between the third pair of sockets is only 1 line less in *Pter. Cuvieri* than in *Pter. Sedgwickii*. It needs only to compare the fore part of the jaw of the Great Chalk Pterodactyle (Pl. 3, figs. 1—4) with the same part of the still larger species from the Green-sand (Pl. 7, figs. 1 and 2), to be convinced of their specific distinction.

The difference is still more marked between *Pterodactylus Sedgwickii* and *Pterodactylus compressirostris* (Pl. 3, figs. 8, 9, 10). The rapid increase of depth as the jaw extends backward, in *Pter. giganteus*, Bk. (Pl. 6, fig. 1), shows that that comparatively small species cannot be the young of the present truly gigantic Pterodactyle of the Upper Green-sand. I have no hesitation, therefore, in basing on the above-described fossil a new species, at present the largest known in the order of Flying Saurians, which I propose to dedicate to the Woodwardian Professor of Geology in the University of Cambridge, who for forty years has discharged the duties of that office with exemplary zeal and a rare eloquence, has almost created the museum still called "Woodwardian," and has enriched geological science by original researches which have thrown light on its most obscure and difficult problems.

The next fossil selected from the Pterosaurian series of Green-sand fossils for present description is the fore part of the jaw figured in Pl. 7, figs. 2, *a*, *b*, *c*, *d*. This contains about the same number of sockets in the same extent of jaw as in fig. 1; and the last four sockets present about the same extent of interspace, with the same diminution of size, as compared with the two preceding sockets. But the walls of these sockets form no lateral expansion, the depth of the jaw is less, and the flat sides converge to a sharper ridge, fig. *c*; the aspect of the sockets is also more obliquely outward, the interspace between the pairs is narrower, and this is traversed by a median groove $\frac{1}{8}$th of an inch across, fig. *b*. Were this specimen a part of an upper jaw, it would indicate a distinct species from *Pterodactylus Sedgwickii*, as exemplified by fig. 1; but I regard fig. 2 as being the fore part of a lower jaw, and consequently as most probably belonging to the same species. The minor depth of the bone accords with the proportions of the lower jaw in *Pter. giganteus* (Pl. 6, figs. 1 and 2) and the sockets are directed more obliquely outward, as they likewise are in the lower jaw of *Pter. giganteus*, as compared with the upper one of the specimen of that species, in which both jaws of the same head have been preserved. In the belief, therefore, that fig. 2, *a*, *b*, represents part of the under jaw of *Pterodactylus Sedgwickii*, the median groove on the upper or oral surface of the prolonged 'symphysis mandibulæ' (fig 2, *b*) suggests that it may have served to lodge a long filiform tongue, perhaps bifurcate at the end, as in the Leptoglossal Lizards of the present day. The same thin outer wall, and capacious cavity filled by matrix, and probably in the living reptile by air, characterise the lower (fig. 2, *c*), as they do the upper, jaws of *Pterodactylus Sedgwickii*. In one of the sockets of the lower jaw part of the hollow base of an old tooth is preserved, with the sharp slender point of a new tooth projecting from the inner side of the socket (Pl. 7, fig. 2, *d*), showing the same relative position of the matrix of the successional tooth, as may be observed in the existing Crocodile.

Pterodactylus Fittoni, *Owen*. Jaws and teeth, Pl. 7, figs. 3, 4, 5.

Figure 3, *a*, *b*, &c., shows the fore part of the upper jaw of a Pterodactyle, with the first and second pairs of alveoli. In the minor depth of the jaw, compared with its basal breadth, in its more obtusely rounded upper surface, and in the greater extent of space between the alveoli of the same size, this maxillary fragment indicates a very distinct species from the *Pterodactylus Sedgwickii*, but one probably not much inferior in size. I propose to dedicate it to my friend, Dr. Fitton, F.R.S., one of the founders of the Geological Society of London, and who may be regarded as the discoverer of the system now called "Neocomian," which includes the Green-sand matrix of the Flying Reptiles under consideration. The sockets in the fragment (fig. 3) may

answer to the second and third in fig. 1, though there scarcely seems room for a pair in advance of the foremost in the specimen figured; be that as it may, the distance between the first and second socket in the specimen of *Pterodactylus Fittoni* is, relatively to the size of the socket, greater than the interval between the second and third sockets in *Pterodactylus Sedgwickii*, and much greater than that between the second and third sockets in fig. 3. The outer wall of the largest anterior socket in *Pter. Fittoni* is much less prominent than in *Pter. Sedgwickii*, and the lateral expansion of the fore part of the upper jaw must have been relatively less; the form of the bony palate is different, there being a distinct though shallow longitudinal groove on each side a low obtuse median ridge. The diastema between the second and third tooth is shown to exceed the long diameter of the second socket, recalling the proportion of the interspaces in *Pterodactylus Cuvieri* (Pl. 3, fig. 4), but the jaw is broader in proportion to its height in *Pterodactylus Fittoni.*

Figure 4, *a* and *b*, Pl. 7, is a fragment of one side of the fore part of the upper jaw, showing three alveoli, and agreeing in general proportions with the *Pterodactylus Fittoni.*

Fig. 5, Pl. 7, is the fragment of a jaw, showing a single elliptical socket, 5 lines in long diameter (*a*), and with the plane inclined a little outward, as at *b*. The widely open cancellous structure of the bone is well shown on the inside of this fragment, as at *c*.

PTERODACTYLUS. Sp. inc.

Pl. 7, fig. 6, is a portion of an upper jaw, including a part of two sockets, in one of which the root of the tooth remains. Three views of this fragment are given, of the natural size: *a* showing the alveolar border, *b* the broken margin exposing the tooth, and *c* the outer wall of the jaw. This part of the wall is nearly flat, very slightly convex below, and as slightly concave above, vertically; the upper margin showing no indication of any bend or inclination to the upper border of the jaw, the height or vertical diameter of which remains conjectural; that it was, at least, one third more than the portion preserved, may be estimated from the extent of the socket of the tooth being equal with the preserved part of the wall (fig. 6, *b*). A coat of roughish 'cæmentum,' one third of a line thick, is preserved upon the upper half of the tooth-root; below this is seen the smooth dentine; and where it is broken, the pulp-cavity is exposed, filled by the Green-sand matrix. The length of the implanted part of this tooth is 1 inch 4 lines, the long diameter of the transverse fracture at the base of the crown is $\frac{1}{2}$ an inch, the short diameter is $4\frac{1}{2}$ lines. Estimating the length of the exserted enamelled crown to equal that of the inserted cemented base of the tooth of a Pterodactyle—and I have known the crown to be of greater length in the anterior

laniariform teeth—we may assign a length of 2 inches 8 lines to the teeth implanted in the part of the upper jaw here described. The interspace between the two sockets is $3\frac{1}{2}$ lines, or half that of the long diameter of the socket; the plane of the opening of the socket, and the interspace, present the same obliquity as they do in *Pterodactylus Sedgwickii* (fig. 1); and as the proportion of the interspace to the socket is also the same, the present fragment has most probably belonged to a larger individual of the same species. Since the outer border of the sockets does not swell out beyond the outer wall of the jaw, the fragment has been part of jaw behind the anterior swelling caused by the proportionally large prehensile teeth; and as, from the analogy of known Pterodactyles, the teeth succeeding those anterior ones are not of larger size, but are usually smaller, at any posterior part of the jaw, we may, therefore, with due moderation, frame an idea of the Pterodactyle to which the maxillary fragment (fig. 6) belonged, as surpassing in size that to which the portion of jaw (fig. 1) belonged, in the proportion in which the socket in fig. 6, *a*, exceeds the last socket in fig. 1, *b*. Such an idea impels to a close scrutiny of every character or indication of the true generic relation of the present fragment in the Reptilian class; but the evidence of the large and obviously pneumatic vacuities, now filled by the matrix, and the demonstrable thin layer of compact bone forming their outer wall, permit no reasonable doubt as to the pterosaurian nature of this most remarkable and suggestive fossil. All other parts of the Flying Reptile being in proportion, it must have appeared, with outstretched pinions, like the soaring Roc of Arabian romance, but with the demoniacal features of the leathern wings with crooked claws, and of the gaping mouth with threatening teeth, superinduced.

The last portion of jaw of a Pterodactyle from the Cambridge Green-sand which will here be described, is that figured in Pl. 7, fig. 7, *a*, *b*, *c*, *d*. It is part of the lower jaw, and indicates a smaller individual of *Pterodactylus Sedgwickii* than the specimens, figs. 1 and 2. In a longitudinal extent of $2\frac{1}{2}$ inches, six successive sockets are shown, but with only the two middle pairs perfect. Their orifices have the same obliquity as in fig. 2; and the surface of the bone between the right and left sockets shows the same median longitudinal groove. Opposite the middle sockets the sides of the jaw are preserved nearly to the median inferior ridge, as shown in fig. 7, *c*; these sides being flat and straight, and giving the transverse section shown at fig. 7, *d*. The intervals of the sockets are a little wider, proportionally, than in some of those in fig. 2, but not more than a hinder position in the jaw would account for, without having recourse to a distinction of species to explain it.

Two species, however, are satisfactorily established, both of them distinct from any of the known large Pterodactyles of the Chalk, by the portions of jaws from the Upper Green-sand near Cambridge, viz., *Pterodactylus Sedgwickii*, with more approximated alveoli (Pl. 7, figs. 1 and 2, with probably 6 and 7); and *Pterodactylus Fittoni* (ib., figs. 3, 4, and 5).

To which of these large species the teeth and bones next to be described belong is not satisfactorily determinable, but indications of their appertaining to more than one such species now and then occur with more or less significancy.

Teeth.

Various teeth, but few quite entire, have been rescued by the care and perseverance of Mr. Lucas Barrett from the rubbish of fragmentary fossils accumulated during the diggings for phosphatic nodules in the Green-sand deposits near Cambridge. Guided by the proportions of length to breadth, by the elliptic section, and the concordance of the minute markings on the crown and base with those on the portions of teeth, as in Pl. 7, fig. 2, *d*, and 6, *b*, remaining in the jaws of *Pterodactylus Sedgwickii*, many of the above detached teeth can be satisfactorily referred to the genus, if not to that particular species.

The base or implanted part of one of the largest of these teeth is figured of the natural size in Pl. 7, fig. 10. It has belonged to a Pterodactyle as large as that represented by the fragment of jaw (fig. 6), if not to the same individual; it presents the same elliptical transverse section as the implanted base of the tooth in fig. 6, *b*; shows a widely excavated pulp-cavity at the base, and gradually tapers to the crown; the cement, about $\frac{1}{3}$d of a line in thickness, is roughened by longitudinal grooves, not continuous for any great length, but uniting, or bifurcating, in an irregular reticulate pattern, forming long and very narrow meshes, the raised interspaces being equal in breadth to the grooves. In a few teeth the base shows an oblique depression, evidently due to the pressure of a successional tooth, as at fig. 8, *o*; in these the basal pulp-cavity is more or less filled up by ossification of the pulp. The enamel of the crown seems smooth and polished, and, under the lens, shows only extremely delicate, slightly and irregularly wavy, longitudinal, but often interrupted or confluent, ridges. The crown is straight in a few teeth, as at Pl. 7, fig. 9, but more commonly it is bent, as it is in the tooth of the great Pterodactyle from the Chalk figured in Pl. 3 (*Pterosauria*), fig. 5. In general, the transverse section of the crown is less truly elliptical than that of the base, owing to its being a little flattened on one side. The smaller teeth, probably from the back part of the dental series, are rather more curved than the larger ones (Pl. 9, figs. 16—20).

If, as is most probable, the median ridge of the bony platform between the alveolar borders characterises the upper jaw, and the median groove of the same part the lower jaw, in the Pterodactyle, the parts of *Pterodactylus compressirostris*, Pl. 3, figs. 8, 9, and 10, will belong to the lower jaw.

Vertebræ of Pterodactylus. Pl. 7, figs. 11—14. Pl. 8.

The most instructive specimens from the Cambridge Green-sand are those which have afforded the precise and hitherto unknown characters of certain vertebræ of *Pterodactylus*. Viewed as indicative of the generic character of these bones, they give the earliest known example of the "procoelian" type of vertebræ in the Reptilian class, being the first cup-and-ball vertebræ, with the "cup" at the fore part of the centrum, met with in the ascending order of strata. It cannot be doubted that this structure prevails in the moveable vertebræ of the neck and back of all *Pterosauria*, and must be predicated of the *Dimorphodon** of the Lias as well as of the *Pterodactylus* of the Green-sand, in which the structure is now clearly demonstrated. The chief difference which the Pterodactyle presents in this respect from modern Lizards is, that both the cup and ball are of a more transversely extended elliptical shape in most of the vertebræ of the flying Saurian.

Amongst the numerous vertebræ submitted to me were specimens of united, or partly united, "atlas and axis."

The atlas consists of a centrum (Pl. 7, figs. 11 and 12, *c*), of two slender styliform neurapophyses (ib., *n*), and of a very small discoid neural spine. The centrum is so short as to be discoid; it is flat where it joins and becomes anchylosed to the axis (*cx*, *x*), and is concave for the occipital tubercle: this cup (Pl. 8, figs. 1 and 5, *c*) is circular; its depth is shown in the section of the anchylosed atlas and axis, Pl. 7, fig. 12. The neurapophyses (*n*), resting on each side of the upper half of the centrum of the atlas, converge and articulate above with two small tubercles, as shown in fig. 13, on the fore part of the neural arch of the axis; the neurapophyses almost meet, but do not unite above the neural canal.

The body of the axis is eight times longer than that of the atlas; it expands posteriorly, and terminates by a transversely elliptical ball (*b*) at the upper part of that end, and in a pair of thick, short, obtuse, diverging apophyses (*p*), at the lower part. There is a rudimental hypapophysial ridge, fig. 12, *h*, from the middle and toward the fore part of the under surface of the centrum; the extent to which this surface descends below the hinder ball, and between the apophyses (*p*), is shown at Pl. 7, fig. 12, *x*.

The centrum of the axis vertebra is confluent with the neural arch, fig. 11, *n*, *x*; at the middle of the side, apparently crossing the line of junction, is a large subcircular aperture, which leads directly into the widely cancellous structure of the bone, below the neural canal. This vacuity (fig. 11, *o*) answers to the "foramen pneumaticum" in the

* 'Reports of the British Association,' 1858.

vertebræ of birds, and doubtless admitted a production from the air-cells extending along the neck of the Pterodactyle into the cancelli of the osseous tissue. The neural arch rests upon the three anterior fourths of the centrum ; it expands as it passes backward ; and there, also, as it rises, until it sends off from each posterior angle the zygapophysis (Pl. 7, fig. 11, *z*), which has a tubercle above, and a flat articular surface below, looking downward and a little outward and backward. The small tubercles at the fore part of the neural arch, shown in fig. 13, to which the neurapophyses of the atlas are ligamentously connected, may be the stunted homologues of anterior zygapophyses. The neural spine begins by a low ridge between those tubercles, increasing rapidly in thickness behind; but it has not been preserved in its full height in any specimen.

In the small atlas and axis figured in Pl. 8, figs. 1—4, the line of suture between the bodies of these two vertebræ is distinct. In a somewhat larger specimen, the centrum of the atlas was separable by a smart blow, and showed the true anterior surface of that of the axis, as shown in Pl. 7, fig. 13 ; this surface is very slightly concave, with a submedian prominence. The neural canal expands at its posterior outlet.

The small atlas and axis (Pl. 8, figs. 1—4) not only differ in size from the specimen (figs. 5 and 6), but also in the smaller relative size of the articular surface of the zygapophysis, and the greater relative expansion of the back part of the centrum : the specimen belongs to another species of Pterodactyle. On comparing the atlas and axis of the Pterodactyle with that of the bird, the Ostrich for example, the atlas in the bird is represented by the neurapophyses, which have coalesced below with a hypapophysis, forming an irregular ring of bone. The centrum has coalesced with that of the axis, forming a small prominence, convex anteriorly, and filling up the vacuity at the upper part of the cup excavated in the fore part of the hypapophysis; the neurapophyses are broad in the bird, and overlap the anterior zygapophyses in the axis; they meet above the neural canal, but long retain the separating fissure there, in the Ostrich; the centrum of the axis is broader before than behind. A short process, like a connate pleurapophysis, from the fore part of the centrum, unites with a diapophysis from the neural arch to form an arterial canal. The pneumatic foramen is behind the diapophysis, and conducts to the cancellous tissue of the neural arch. The centrum is produced into a strong hypapophysis below the posterior articular surface; but not expanded laterally into transverse processes, answering to parapophyses, in the Pterodactyle. The hinder articular surface of the centrum of the axis in the bird is convex transversely, but concave vertically, not simply convex, as in the Pterodactyle; thus a portion of the vertebra of that reptile, notwithstanding its pneumatic structure, might be distinguished from the vertebra of a bird.

In the ordinary neck-vertebræ of the Pterodactyle the centrum is oblong, subdepressed, slightly compressed at the middle, subcarinate (Pl. 8, figs. 11, 12, *h*), or with a low obtuse hypapophysis (fig. 18) at the fore part of the under surface,

which expands laterally to join the base of the anterior zygapophyses (ib. *a*). The back part of the centrum expands and bifurcates into the short, thick, obtuse parapophyses (figs. 11 and 18, *p*), the anterior concavity (fig. 10, *c*) is a long transverse oval, with the upper border somewhat produced: the hinder ball (fig. 8) has a similar transversely extended elliptical figure, directed a little upward; it appears to be tilted up by the curve of the under surface of the centrum, above the level of the terminal tuberous parapophyses (*p*). A large pneumatic foramen (figs. 7, 13, 15, *o*) of an elliptic form, opens upon the middle of each side of the centrum, close to the anchylosed base of the neurapophysis. The texture of the centrum (fig. 19) presents a few very large cancelli, which communicated by the pneumatic foramen with the cervical air-cells. The smooth outer wall of the centrum is a very thin but compact plate of bone: it becomes a little thicker where it forms the articular cup and ball.

The neural arch, between the notches of the nerve-outlets, is not quite two thirds the length of the centrum. The hinder notch is the deepest; the arch is low, broad exteriorly, less concave on each side than it is before and behind (Pl. 8, fig. 17), with the four angles somewhat produced, and supporting the articular surfaces, of which the two anterior (fig. 18, *a*) look upward and inward, the two posterior (fig. 16, *z*) downward and backward. The sides of the neural arch extend outward so as to overhang those of the centrum (fig. 18). The posterior zygapophyses (*z*), do not extend so far back as the articular ball of the centrum.

Figs. 7 to 11 give five views of the natural size of a middle cervical vertebra, which, according to the proportions of *Pterodactylus suevicus*, Qnstd.,* may have belonged to a Pterodactyle with a first phalanx of the wing-finger of about one foot in length. In another specimen, fig. 12, the under surface of the centrum is well preserved; it differs from that of the larger cervical vertebra (figs. 7—11) in being flatter from side to side, and in being concave instead of convex from before backward; the concave contour being due to the median production, gradually extending into the obtuse hypapophysis (*h*) at the fore part. This difference indicates that the present vertebra had a more advanced position in the cervical series than fig. 7, which may probably have been the sixth. The superior breadth of the neural arch over the centrum is well shown in fig. 12; and the relative positions of the zygapophysis (*z*), the articular ball (*b*), and the parapophysis (*p*), at the hinder end of the vertebra, are seen in fig. 13, which is a side view of the same specimen.

Figs. 14, 15 and 16 show a smaller cervical vertebra, of a more depressed form, not due to crushing. The centrum is much depressed; the pneumatic foramen (fig. 15, *o*) partakes of the same modification of form, and is a longer ellipse than in the vertebra (fig. 7); the neural canal retains its normal cylindrical shape, with slightly expanded outlets. The form of the posterior zygapophysis is perfectly preserved on one side, in fig. 11, *z*, and the articular surfaces on both sides in fig. 16, *z*; they are

* Quenstedt, 'Ueber *Pterodactylus suevicus*,' 4to, 1855.

relatively larger than in fig. 11. In fig. 15 more of the base of the neural spine remains than in most other specimens.

Figs. 17 and 18 are of a rather shorter and probably more advanced cervical vertebra, but of very similar proportions; in it the neural arch (fig. 17) is more entire than in most specimens, the anterior (*a*) as well as posterior (*z*) zygapophyses being preserved; the more frequent loss of the anterior pair is due to their being more slender and more produced. The under surface of the centrum (fig. 18) shows no rising of the part midway between the two ends, the hypapophysis having a less extended base than in the vertebra, (fig. 12). The inner surface of the anterior zygapophysis (fig. 18, *a*), is divided by a notch from the border of the articular concavity of the centrum.

Fig. 19 gives a view of a section of a mutilated cervical vertebra, nearly equal in size with fig. 7, and similar in form. The shape of the neural canal, the large cancelli, and the thin superficial compact crust of the bone, are well shown in this section.

At the base of the neck, or beginning of the back, the vertebræ suddenly decrease in length; the hypapophysis disappears, or is represented only by a slight production of the lower border of the anterior cup; the hind parapophyses are less produced, the lower surface of the centrum is flattened, and presents the quadrate form shown in figure 20. There is now a considerable development from the fore part of each side of the neural arch and contiguous part of the centrum, and thereby the last cervical or first dorsal vertebra of the Pterodactyle more resembles the corresponding vertebra of the bird. A front or proper parapophysis, a diapophysis, and a rudimental rib are present on each side, and coalesce around the vertebraterial foramen; an oblique ridge is continued from the upper border of the anterior articular cup upon the parapophysis; a parallel oblique ridge is continued from the anterior zygapophysis downward and outward upon the pleurapophysis; the diapophysis makes a low obtuse projection above the pleurapophysis and behind the zygapophysis. Above these developments the neural arch contracts from before backward, to an extent of 5 lines, as compared with a total vertebral breadth, anteriorly, of 1 inch 8 lines; it then rapidly expands, rising vertically at its fore part, and developing at its back part the posterior zygapophyses, the articular facets of which look more directly outward than in the long cervical vertebræ; the superincumbent tubercle (Pl. 8, fig. 22, *c*) is more distinct from the facet (ib., *z*); the posterior zygapophyses are also much more approximated than in those vertebræ; they are separated behind by a semicircular concavity; the base of the neural spine in the vertebra here described measured 6 lines in length by 3 in breadth. The pneumatic foramina are at the back part of the base of the diapophysis, as I have seen them in the cervical vertebra of a *Dinornis*. The articular surfaces of the centrum retain the transversely extended form, and are simply concave before and convex behind, which at once distinguishes the Pterosaurian hind-cervical vertebra from that of the bird.

In the dorsal region the vertebral centrum (Pl. 8, fig. 24), retaining its shortness, gains in depth, and presents the more usual proportions of cup-and-ball reptilian vertebræ. The under surface (fig. 20) is smooth and even, very slightly concave lengthwise, convex transversely. The parapophysis disappears, and the diapophysis, which alone supports the rib, after the first or second dorsal, is sent off from a higher position in the neural arch (fig. 25).

Sacrum.

Pl. 8, fig. 26, shows parts of the bodies of three anchylosed sacral vertebræ, the first being demonstrated by part of its anterior concave articular surface (*a*) for the last lumbar vertebra. The groove for the passage of the nerve notches the back part of the parapophysis, close to the line of suture with the second sacral. In this vertebra the corresponding nerve-notch is more advanced, leaving a short sutural surface behind, indicative of a position of the neural arch crossing for a short extent the line of junction of the second with the third sacral centrum. The parapophyses of the second and third are sent off almost on a level with the lower surface of the centrum, which is flattened.

The fore part of the sacrum of a much larger Pterodactyle, from the Cambridge Green-sand, differing also in the less transverse convexity of the under part of the first centrum, measures 11 lines across the shallow anterior articular concavity, and 14 lines from the lower part of the centrum to the fore part of the base of the neural spine. The neural canal is circular and 2 lines in diameter; above it the neural arch rises like a vertical wall for 5 lines, where the spine has been broken off.

Caudal Vertebræ.

From the number of elongated caudal vertebræ in the series of fossils from the Cambridge Green-sand submitted to me—not fewer than seven—I believe the large Pterodactyle from that formation to have had a long tail, but moveable, not stiff through anchylosis of the vertebræ, as in *Pter.* (*Ramphorhynchus*) *Gemmingi*, *V.* Meyer.

The largest of these caudal vertebræ measures $1\frac{1}{2}$ inch in length; it is slightly contracted in the middle; the fore part of the under surface is a little produced; the back part almost flat between the rudimental parapophyses; the shallow anterior concavity has resumed its transversely elliptical shape, and the hinder convexity is

defined below by a shallow groove connecting the parapophyses. There is no pneumatic foramen, unless a small hole on each side the hinder outlet of the neural canal have served as such; the neural arch is long and low, quite one piece with the centrum, which extends beyond it posteriorly. It sends off short, obtuse zygapophyses before and behind, those in front extend beyond the cup of the centrum; the surfaces on those behind look downward and backward. The base of the spine is coextensive with the summit of the arch, but is narrow. The neural canal is much contracted. There is no indication of a hæmal arch, either by articular or fractured anchylosed surfaces. The diameter of the middle of this vertebra is 6 lines.

The caudal vertebra next in size measures 1 inch 5 lines. The base of the neural spine begins 2 lines behind the fore part of the arch, but terminates nearer the hind part; the nerve-grooves notch the hinder zygapophyses.

Three more slender caudal vertebræ present each a length of 1 inch 3 lines; the diameter at the middle is 5 lines in one, 4 lines in a second, $3\frac{1}{2}$ lines in the third vertebra, showing that they become more slender without losing length. A caudal vertebra 3 lines across the middle appears to have been nearly an inch in length; but both extremities are injured.

Frontal Bone (?). Pl. 10, figs. 6, 7, 8.

As it is probable that the median symmetrical portion of bone (Pl. 10, figs. 6, 7 and 8) may belong to the cranium of one of the large Pterodactyles from the Upper Green-sand, its description follows that of the vertebræ.

It is 2 inches 4 lines long; 10 lines across its broadest part; 1 inch 2 lines in depth, to the surface where the piece has been broken away; the sides present a smooth concave plate of bone (fig. 6), as if the piece had been nipped between a finger and thumb, but quite symmetrically; the surface, which, on the supposition that those smooth concave facets were inner walls of the orbits, would be the upper one, and due to the frontal bone, is gently convex in the direction of its length, and has a median longitudinal ridge, which expands and subsides near the end most produced beyond the lateral depressions. I have observed a similar median ridge or rising upon the single frontal bone of the *Alligator lucius*, between the orbits, and upon the double frontal, supporting the median suture, in the *Rhynchocephalus* lizard of New Zealand. There is also an indication of such a median ridge in the figure of the cranium of *Pterodactylus suevicus*, in Professor Quenstedt's Memoir on that species (4to., Tübingen, 1855).

The most perfectly preserved of the lateral impressions (fig. 6) is of an oval form, 1 inch 3 lines in long diameter; it is well defined from the narrower upper surface (fig. 7) to which it stands at nearly a right angle; the curved border defining it is not

produced. The whole of the substance of the bone between the lateral plates is occupied by a moderately open and apparently pneumatic cancellous texture (fig. 8); the outer wall of bone is compact, but extremely thin; the general structure is decidedly that of a volant Vertebrate, and most resembles that of a Pterodactyle.

The parts of the skeleton of the Pterodactyle which would afford a symmetrical median piece of bone, comparable with the present fragment, are—the sternum, the fore part of the upper and lower jaw, the sphenoid at the base of the skull, and the parietal and frontal bones at the upper part of the skull. The absence of any trace of cranial cavity at the lower fractured surface, more than an inch below the outer surface, opposes the choice of the parietal with lateral impressions of temporal fossæ: there remains, therefore, the frontal with the interpretation of the lateral depressions as parts of the orbits; but the depth of the smooth impressed plates, and their divergence as they descend, oppose this interpretation. I have no evidence of sternal ends of coracoids which would require articular depressions of such size and shape as the lateral ones on the fragment in question, on the hypothesis that it may be from the fore part of the sternum. Upon the whole, therefore, I have to acknowledge a degree of uncertainty as to the exact nature of the present fragment of the skeleton, most probably, of some large Pterodactyle.

Scapular Arch. Pl. 9, figs. 1—6.

The mechanism of the framework of the wings in the Pterodactyle is much more bird-like than bat-like. The scapular arch is remarkably similar to that of the bird of flight. It consists of a scapula and coracoid, usually anchylosed where they combine to form the shoulder-joint.

The cavity for the head of the humerus, in *Pterodactylus macronyx** (Pl. 9, fig. 6), is oval, with the great end formed by the scapula; it is concave vertically, or in the direction of its long diameter, convex transversely, but least so near the scapula. If these proportions hold good in other species, they would serve to determine the scapular or coracoid portion of a glenoid cavity, when, as in the case of the fossils here described, the rest of the scapular arch had been broken away.

The upper (scapular) border of the glenoid cavity is prominent and well defined; the bone is moderately constricted beyond it, from without inward, whence the scapula extends upward and backward, as a slightly bent sabre-shaped plate, a little twisted on itself. The coracoid is thicker, straighter, and shorter than the scapula;

* Buckland, 'Geological Transactions,' 2d series, vol. iii, pl. xxvii, x, 9.

it is rather suddenly expanded at the sternal end, where it is most compressed: the scapular end developes a protuberance below the glenoid cavity.

The scapular arch in *Pterodactylus giganteus*, Bwk., from the Chalk of Kent (p. 247, Pl. 6, fig. 7), was distinguished by a tuberous (acromial) process from the scapula, near the glenoid cavity, the corresponding anterior process from the coracoid being also well marked.

The fossil fragment from the Cambridge Green-sand (Pl. 9, figs. 1 and 2) consists of the coalesced extremities of the scapula (*a*) and coracoid (*b*), where they form the glenoid cavity for the humerus. The margins of the cavity are in part abraded, but its long diameter cannot have been less than 1 inch 3 lines; it is concave vertically, rather convex transversely below, but plane, or a little concave, in that direction at the upper or scapular end. The cavity is transversed obliquely by a depression pretty equally dividing it, and indicating the respective shares of the scapula and coracoid in its formation prior to the anchylosis of those two bones. The end of the scapula, near the cavity, would present an unequally three-sided figure in transverse section, the side looking inward and that looking forward being concave, the side looking outward convex. Half an inch above the border of the glenoid cavity is the fractured base of the (acromial) process answering to that in *Pterodactylus giganteus*, but which is more feebly developed in *Pterodactylus macronyx*, Bkd., and *Pterodactylus suevicus*, Qnstd. Beyond this process the bone rapidly contracts in size, and presents an oval transverse section, as at *a*, fig. 2, Pl. 9.

The surface of the coalesced extremities of the bones which is applied to the thorax is concave in every direction, and an inch in breadth, with a long narrow (pneumatic) aperture near its hinder border. The anterior production of the coracoid has been broken away at *c* (figs. 1 and 2), the coracoid quickly contracts as it recedes from the humeral articulation to a size and shape shown by the section *b* (fig. 2). The size of the entire scapular arch, according to that of *Pterodactylus macronyx*, is shown by the dotted outlines in fig. 1.

Fig. 3 shows the articular surface of the scapular arch of a Pterodactyle of larger size than the preceding specimen; the oblique groove indicative of the portions contributed by the scapula and coracoid to the cavity is well marked, as it also is in the corresponding fragment of the scapular arch of the smaller Pterodactyle (fig. 4). In the still smaller but similar fragment of the scapular arch (fig. 5), the posterior concave surface shows the long (pneumatic?) foramen very distinctly, and also a trace of the primitive separation of the scapula and coracoid. If this specimen has belonged to a young individual of either of the two larger species, it shows that the union of the two bones takes place at an early age. In the bird, although the early and extensive coalescence of originally distinct bones is a characteristic of the skeleton, the scapula remains distinct from the coracoid, and the persistent suture traverses the

glenoid cavity. The coracoid is shorter and straighter in birds than in Pterodactyles, but is commonly broader, and with a longer and stronger anterior process.

Humerus.

The portion of bone figured of the natural size in Pl. 9, fig. 7, shows an articular surface of a reniform figure, convex in its shorter diameter, less convex upon the more prominent half, lengthwise, and slightly concave lengthwise at the side which is hollowed out. The smaller end of the surface (*a*) has been produced into a process, here broken away, and the fracture is coextensive with the length, in the direction of the shaft of the bone, of the fragment, which is nearly two inches; the larger end of the articular surface (*b*) seems not to have sent off such a process; but the back part of this end is broken away. The pterosaurian nature of the fragment is shown by the thinness of the compact wall of the shaft below the articular surface, and by the wide cancelli. The general resemblance of the articular surface, in shape, to that of the humerus of the Wealden Pterodactyle (*Pt. sylvestris*, Ow.) figured in the 'Quarterly Journal of the Geological Society,' Dec., 1845, vol. ii, p. 100, fig. 6; and to that of the more complete humerus of *Pterodactylus suevicus*, Qnstd., loc. cit., but especially to the articular surface of the portion of bone of a smaller Pterodactyle (Pl. 9, figs. 14 and 15), which exhibits more distinctive characters of a humerus, have led me to refer the fragment in question (fig. 7) to the proximal end or head of that bone in one of the large species above established by maxillary characters.

The end of the articular surface (*a*) answers to the outer plate or process (*g*) in *Pterodactylus sylvestris*, and the fractured surface behind the end (*b*) might well have been the base of a shorter and thicker process, like that marked *f* in *Pter. sylvestris.* Determining, by these analogies, that *a* is the outer or radial, *b* the inner or ulnar, end of the transversely extended head of the humerus; that the convex side is the fore part, and the concave one the back part, of the same bone; it may next be remarked that the inner half of the fore part of the articular surface is extended further and more convexly upon the shaft than the outer half, which meets the vertical plane of the shaft more abruptly; but the form of this part of the head of the humerus is better shown in the next specimen.

This fragment (fig. 8) is the head of the opposite humerus of a Pterodactyle of equal size with the preceding. The boundary of the articular surface near the outer process (*a*) is very slightly raised, with a few short ridges at right angles, indicative of the firm attachment of the capsular ligament; an oblique line divides the more abruptly defined outer half of the surface from the inner anteriorly more convex

half. The anterior surface of the fore part of the shaft of the humerus, here preserved, is impressed by longitudinal reticulate markings. The total length of the humerus, according to the proportions of the length of that bone to the breadth of its proximal articular surface in *Pterodactylus suevicus*,* would be 10½ inches.

Fig. 9 shows well the minutely punctate surface of the articular head of the humerus; the portion of the fore part of the shaft preserved with this shows that the fine reticulate markings are limited to a short distance below the head, and that the rest of the outer surface of the shaft here preserved is smooth. The extent of the base of the outer plate or process is 1 inch, the long diameter of the articular surface of the head being 1 inch 3 lines.

The fragment of the head of the humerus (Pl 9, fig. 10) is remarkable for the well-defined ridge bounding the anterior convex part of the articular surface.

The proximal end of the smaller humerus (fig. 11) includes nearly two inches of the shaft, of which a front view is given in fig. 12, and a back view in fig. 13. The base of the outer process (*g*) shows the same proportion to the long diameter of the head, as in fig. 9. The fractured surface along the opposite side of the shaft (*f*) seems to show that this border had been produced into a ridge or plate, with a greater extent of origin. The back part of the shaft between these plates is concave transversely, but rather convex lengthwise; the opposite conditions prevail on the fore part of the bone. Here, towards the base of the outer process, is a small, apparently pneumatic, oblong foramen.

The smaller proximal end of humerus (figs. 14 and 15), shows a larger proportion of the process (*f*) which extends the bone in that direction beyond the articular head.

All these specimens show that, in the Pterodactyles from the Green-sand, there is a plate or process with a shorter base, situated close to the articular surface of the head of the bone; and that there is a plate, with a longer base, extending farther from the articular head down the shaft at the opposite side of the bone; this latter plate was more produced than the other, and was bent obliquely backward.

The fragment (figs. 1, 2, and 3, Pl. 10) shows part of the articular extremity of one of the long bones of the wing. The articular surface has been partially divided into what might be called, were they entire, two condyles (*a* and *b*). The most perfect of these divisions shows a slightly convex surface (figs. 1, and 2, *a*, *a*,) occupying its major part, and a small well-defined flat surface (figs. 1, and 3, *c*,), placed obliquely. So much of the other division as is preserved likewise shows two facets;

* See the plate in Quenstedt's 'Memoir,' above cited.

one, which we may call the anterior (fig. 1, *d*), is convex and of small extent, and behind it is a well-defined part of a concave surface (*b*). At the fore (?) part of the bone (fig. 2) the two convex surfaces extend a little upon the shaft (*a*), and are divided from each other by a moderate median depression; where the thin smooth outer crust of bone has been worn away, the small superficial cancelli are exposed. At the back (?) part (fig. 3), where the major part of the bone is broken away, the larger cancelli are exposed.

Guided by considerations of size, the fragment (Pl. 10, figs. 1—3) might form the opposite end of the bone indicated by the articular ends (Pl. 9, figs. 7 and 8). I am not acquainted with the precise configuration of the distal end of the humerus, in any Pterodactyle; indeed, the articular surfaces of very few of the bones of this remarkable reptile have been perfectly preserved, so as to be recognisably delineated and described. From general analogy, however, one should scarcely be prepared to find so feeble an indication of divisions into condyles, an absence of general convexity, and a presence of a well-defined concavity in one condyle, and as well-defined a flattened or feebly concave facet in the other condyle, of the distal end of a humerus. The form of articulation above described would seem rather to be that of the end of an antibrachial bone adapted to join the bones of a carpus. But, on the hypothesis of the fragment in question being either proximal or distal, and of a radius or ulna, it expands our ideas of the bulk of the Green-sand Pterodactyle even beyond those suggested by the manifestly head of the humerus (Pl. 9, fig. 7). The present description and figures will at least help, it is hoped, to forward a precise knowledge of the osteological characters of the *Pterosaurians*.

Assuming that we have in figs. 1—3, Pl. 10, the articular end of an antibrachial bone, then, according to the proportion which the broadest end of one of these bones bears to its total length in the *Pterodactylus suevicus*, the length of such antibrachial bone in the great Pterodactyle of the Green-sand here indicated would be 16 inches. The total length of wing will be calculated on this basis at the conclusion of the present Supplement.

The fifth or wing-metacarpal.

The trochlear joint of the bone (Pl. 10, figs. 9—11) belongs to the distal end of the metacarpal of the fifth or wing-finger. The pulley is more complex, in the large Pterodactyles here described, than it is in similar trochlear joints of other animals; there are three convex ridges, *a*, *b*, *c*, which traverse the articular surface from behind forward, describing rather more than half a circle; the middle ridge, *c*, is less prominent, and of less extent than the lateral ones which form the sides of the pulley. The direction of the ridges is rather oblique, and one which, to help the description, may be called

the outer ridge, is rather more produced and of a less regular curve than the inner ridge. The outer ridge, *a*, begins by a rising at the middle of the fore part of the distal end of the shaft, which bends obliquely outward and meets the outer angle of that part of the shaft where the outer trochlear ridge begins to be prominent; this ridge then extends with a feeble convex curve to the back part of the trochlea, where the convexity of the curve increases, and it terminates by projecting a little beyond the level of the outer almost flattened side of the trochlea (fig. 10). The articular surface, as it extends from the margin of this element of the trochlea inward, is first gently convex, then sinks to a concave channel by the side of the low median convexity. The inner ridge *b*, begins from the inner side of the fore part of the bone, and describes a pretty regular semicircular curve as it extends backward and a little outward, to terminate near the middle of the back part of the distal end of the shaft; thus owing to the termination of the inner ridge near the middle of the back part, and to the beginning of the outer ridge near the middle of the fore part, of the metacarpal bone, these principal ridges of the trochlear joint recede from each other at the middle of the joint, and approximate at the fore and back ends of the joint. As the back ends of the two lateral ridges are on the same transverse line, and the front end of the inner ridge rises higher upon the shaft than that of the outer ridge, this is by so much the shorter of the two. The low middle ridge *c*, is much shorter than either of the lateral ones, being confined to the lower and middle part of the trochlea, to which it gives an undulating transverse outline (fig. 11).

The figure of the metarcarpal bone of the wing-finger, in *Pterodactylus suevicus*, Qnstd., does not show any trace of the mid-rising of the distal trochlear joint. The back surface of that of the left wing shows a wide and moderately deep excavation along the upper three fourths of the shaft. A portion of a similarly shaped shaft of a long bone, in size matching that of the trochlear extremity (fig. 10), is represented in Pl. 10, figs. 4 and 5. Although both ends are broken away, yet the degree of expansion toward the upper end shows that this was not very far from the proximal articulation. The shaft is three-sided; two of the sides are nearly flat or very feebly convex; they meet anteriorly at an acute angle, but this is rounded off as shown in the transverse sections of figs 4 and 5; the third and shorter side is concave in the degree shown in the same sections. The lower of these (fig. 5), indicates the extreme thinness of the compact wall of the bone, and the size of the cancelli occupying that part of the shaft.

The portions of the wing-bones of the Pterodactyles of the Cambridge Greensand, here described and figured, show the same superior proportions over those of the great Pterodactyles from the Kentish Chalk, described and figured in a former Chapter, as do the portions of jaw bones and teeth.

The long diameter of the largest of the wing-bones, figured in Pl. 4, fig. 1,

e.g., is 2 inches 2 lines; that of the wing-bone, figured in Pl. 10, figs. 1—3 of the present Supplement, is 3 inches. The transverse diameter of the distal end of the humerus of *Pterodactylus grandis*, Cuv., the largest species hitherto obtained from the Lithographic Slates of Germany, is 1 inch 3 lines; neither the radius, ulna, or metacarpal of the wing-bone of the same species presents a diameter of its largest end equalling 1 inch.*

The articular end of the long wing-bone, (Pl. 10, figs. 1—3), being most probably that of an antibrachial bone, and the total length of the bone, whether radius of ulna, being, according to the proportions of either of these bones in *Pterodactylus suevicus*, 16 inches, the following would be the length of the other long bones of the wing in the large Pterodactyle to which the above-cited specimen belonged, according to the proportions which those bones bear to the radius or ulna in *Pterodactylus suevicus.*—

	Ft.	In.	Lines.
Humerus	1	0	0
Radius	1	4	0
Metacarpus of wing-finger	1	8	0
First phalanx of do.	2	3	0
Second do. do.	1	9	0
Third do. do.	1	5	0
Fourth do. do.	1	1	0
Total length of long-bones of one wing	10	6	0

Supposing the breadth of the Pterodactyle between the two shoulder-joints to be 8 inches, and allowing 2 inches for the carpus and the cartilages of the joints of the different bones, in each wing, we may then calculate that a large *Pterodactylus Sedgwickii* would be upborne on an expanse of wings of not less than 22 feet from tip to tip.

I look forward with confidence to future acquisitions of remains of the truly gigantic Pterodactyles of the cretaceous periods, more especially from the Greensand locality near Cambridge, as a means of throwing more light on the peculiar osteology of the extinct flying reptiles.

For the opportunities at present afforded me, I have to express most grateful acknowledgments to my old and much esteemed friend the Rev. Professor Sedgwick, F.R.S.; to the acute and active curator of the Woodwardian Museum, Mr. Lucas Barrett, F.G.S.; to James Carter, Esq., M.R.C.S., Cambridge; to T. W. Beddome, Esq., of Trinity College, Cambridge; and to the Rev. G. D. Liveing, M.A., of St. John's College, Cambridge; to whom I am indebted for the lower jaw of *Pterodactylus Sedgwickii* (Pl. 7, figs. 2, *a*, *b*, *c*, *d*).

* These admeasurements are derived from the excellent figures of a recently acquired specimen, well described by Professor ANDREAS WAGNER of Munich, in the "Abhandlungen der Kais. Bayer. Akademie der Wissenschaft," Band. iii, p. 663, taf. xix.

CHAPTER II.—Order—*CROCODILIA.*

Genus—Streptospondylus, *Von Meyer.*

This name, from the Greek *στρέφω*, I turn, *σπονδύλος*, vertebra, was applied by M. Hermann v. Meyer to the Crocodilian reptile distinguished by Cuvier as the "seconde espèce de Crocodile de Honfleur,"* and characterised by the same great anatomist as "having the cervical and anterior dorsal vertebræ, with the articular ends of the centrum, convex in front and concave behind."† By this character was distinguished the "second Gavial of Honfleur" from a "first Gavial of Honfleur," in which the articular ends of the centrum were both slightly concave.

With regard to these kinds of fossil vertebræ Cuvier writes: "je nommerai l'un *système convexe* en avant, et l'autre *système concave.*"‡ To the former he referred a gavial-like skull, with a shorter and more obtuse upper jaw, and a less depressed symphysis of the lower jaw;§ to the latter a more gavial-like skull, with longer and more slender jaws.‖

Certain vertebræ of the "anteriorly convex" system were further distinguished by the origin of the transverse process from salient ridges converging so as to form a pyramidal base of such process, and by a deep depression behind the costal facet. These characters are peculiar to the anterior dorsal vertebræ. In the posterior dorsal and lumbar vertebræ, recognised by Cuvier as belonging to the same "seconde Gavial de Honfleur" by the character of the pyramidal base of the transverse process, the anterior convexity had subsided: even in a dorsal vertebra, in which the articular surface for the head of the rib is still distinct, only a little higher placed, the terminal articular surfaces of the centrum are nearly equal and flat, "a peu près égales et planes."¶

* 'Ossemens Fossiles,' ed. 8vo, 1836. Explication des Planches, p. 78, pl. ccxxxviii, figs. 5, 6, et 7.

† Ib., t. ix, p. 309.

‡ Ib., p. 308.

§ Subsequently named *Steneosaurus rostro-miňor*, by Geoffroy St. Hilaire.

‖ *Steneosaurus rostro-major*, ib.

¶ 'Ossemens Fossiles,' tom. cit., p. 311.

Upon the discovery of "opisthocœlian" vertebræ, or those of the "système convexe en avant" in the Wealden formations,* I threw out the suggestion † that, as in the second Honfleur Gavial, they might be the anterior vertebræ of a large Wealden Saurian, having vertebræ with flattened terminal surfaces in a more posterior part of the spine. Observing, also, that such vertebræ, in the *Cetiosaurus brevis*, were slightly concave behind, though flat in front, it seemed to me that this genus might have the best claim to them. But, after pointing out the difference in the antero-posterior diameter of the large convexo-concave and plano-concave vertebræ, I remarked that "additional evidence of a very decisive character must be obtained before the great Cetiosaur can be admitted to have resembled the Pterodactyle in such disproportionate length of the cervical vertebræ."‡

No discovery of the long convexo-concave or opisthocœlian vertebræ, so associated with short plano-concave or bi-concave vertebræ, as to have belonged to the same animal, has yet been made, though nearly twenty years of quest and collection of Wealden fossils have passed since the importance of that additional evidence was pointed out. I, therefore, still feel myself without the requisite grounds for a decisive settlement of the question of the genus of the long and large opisthocœlian vertebræ of the Wealden, and continue to refer them, provisionally, as in my 'Report,' to a species of *Streptospondylus*.§

STREPTOSPONDYLUS MAJOR, *Owen*. Pls. 31 and 32 (*Crocodilia*).

The vertebræ so named, in the British Museum, and in that of the late Mr. Saull, F.G.S., now transferred to the Literary Institution, Aldersgate Street, London, have belonged to the region of the neck, or fore-part of the back, and were obtained from the Wealden formation of three localities, viz., Tilgate Forest, in Sussex; Culver Cliff,

* Previous to my Report on British Fossil Reptiles, 'Trans. British Association,' 1841, these vertebræ had been deemed "procœlian;" and, in the question of which of the various-shaped Wealden vertebræ might belong to the *Iguanodon*, Dr. Mantell thought that "the concavo-convex vertebræ which correspond so entirely to those of the *Iguana* and *Monitor*, would seem to offer a more probable approximation" ('Geology of the South-east of England'); only their extreme rarity opposed the hypothesis.

† 'Report on Brit. Fossil Reptilia,' ib., p. 96.

‡ Ib.

§ Report on British Fossil Reptiles, 'Trans. Brit. Association,' 1841, p. 91. The futility of subsequent speculations on this subject, in the 'Philosophical Transactions' of 1849, p. 286, has been shown by the discovery of the true cervical vertebræ of the *Iguanodon*, described in Chapter I of the present Section.

Isle of Wight; and Brook Point, Isle of Wight. They differ from the convexo-concave vertebræ of *Streptospondylus Cuvieri*, from the Lower Oolite and Lias (Pl. 20), in their much larger size, and in the absence of the deep pit behind the costal facet. The converging, buttress-like ridges on the sides of the neural arch appear to be developed only in the anteriorly convex vertebræ of the dorsal region (Tab. VI, fig. 5, *a*, *b*).

Cervical vertebræ. Pl. 31, figs. 1 and 2. Pl. 32, figs. 1, 2, and 3.

The cervical vertebra (Pl. 31, figs. 1 and 2) measures six inches in length. The anterior end of this vertebra is determined by the aspect and position of the zygapophysis (ib. *z*), which, as its articular surface looks obliquely upward and inward, and is on a lower level than the oppositely turned process (*z'*), must be the anterior one. The corresponding extremity of the centrum (ib. *b*) is convex; the opposite extremity, which is somewhat overhung by the higher placed posterior zygapophyses (*z'*), is concave, as shown in fig. 2, *c*. The whole vertebra is a little crushed obliquely. The fore part of the centrum is further indicated by the position of the parapophysis (ib. figs. 1 and 2, *p*) or transverse process for the articulation of the head of the rib; at least, according to the analogy of the *Crocodilia*, in which it comes off nearer the anterior than the posterior end of the centrum.* Beneath the parapophysis (*p*) the sides of the centrum are concave, and converge downward to a broad ridge (Pl. 32, fig. 2, *h*), which terminates (at *h*) the anterior part of the lower surface of the vertebra, and corresponds with the hypapophysis given off from that part in the cervical vertebræ of the Crocodile.† A second concavity, at the upper part of the side of the body, separates the parapophysis from the base of the neural arch; from which a diapophysis (upper transverse process) is developed for the attachment of the tubercle of the rib. The diapophysis (Pl. 31, fig. 1, *d*) comes off from the under and outer side of the anterior zygapophysis (ib. *z*). The articular facet of the latter process presents a full, oval figure; it is slightly raised at its outer part from the horizontal position. There is but little trace of spinous process from the somewhat fractured summit of the neural arch; this appears to be truncate in front, but has suffered some injury there, permitting the fore part of the neural canal and the whole anterior articular ball to be seen in a direct vertical view (as in figs. 1 and 3, Pl. 32). The back part of the neural arch appears to be deeply cleft through the backward production and divergence of the posterior zygapophyses.

* See Section I, Chapter ii, p. 120, pl. 1D, fig. 3, *p*: (*Crocodilus Hastingsiæ*).

† Ib., figs. 2 and 4.

In the collection of fossils of the late Mr. Saull, F.G.S., now in the Museum of the Literary Institution, Aldersgate Street, London, there is a cervical vertebra of *Streptospondylus major*, associated, as in the Mantellian Collection, with vertebræ of the *Iguanodon* and *Cetiosaurus*, all of which have been washed out of the submarine Wealden beds at the south side of the Isle of Wight, and thrown on shore near Culver Cliffs and Brook Point.

The lower half of the sides of the centrum of this vertebra of the *Streptospondylus* are, like the preceding vertebra from Tilgate, concave and obliquely compressed, so as to converge to the anterior part of the under surface (Pl. 32, fig. 2), which thus presents a triangular form, with the apex forming the obtuse anterior ridge (*h*), and the base turned backward and becoming somewhat flattened. Each lateral concavity is bounded above by a short but broad parapophysis (ib. *p*), developed from the anterior half of that part of the centrum, and terminated by an oblong flattened surface for the articulation of the head of the cervical rib; which surface is about twice as long in the antero-posterior as the vertical direction. Above this process the centrum is again concave, but there is no pit or defined cavity behind its process. The base of the neurapophysis is anchylosed to nearly the whole antero-posterior extent of the centrum, the course of the original straight suture being, however, discernible. A diapophysis is developed from the side of the base of the neurapophysis, affording a broader surface for the tubercle of the cervical rib than does the parapophysis for the head. Above the diapophysis the neurapophyses converge obliquely to the base of the spinous process. The line of the base of the spine inclines forward, and the thickness of the spine diminishes in the same direction. The posterior zygapophyses in the cervical vertebra from Culver Cliff, are similar in all respects to those in the Tilgate specimen, and equally determine the fore and hind extremities of the vertebra.

The difference in the height of the neural arch, and in the configuration of its external surface, which both the cervical vertebræ of the great Wealden *Streptospondylus* present, when compared with the dorsal vertebræ of the smaller species from the older oolitic formations,* is very great; and the more remarkable, as in the existing Crocodiles the height of the neurapophyses is greater in the cervical than in the dorsal region. Since, however, the diapophyses in the Crocodiles come off from a higher part of the neural arch in the dorsal than in the cervical vertebræ, the spine of the great Wealden *Streptospondylus* may possibly present modifications in the dorsal region corresponding with those remarkable ones which Cuvier has described in the vertebræ from Honfleur.

A more posterior cervical vertebra of *Streptospondylus major* (No. 28,708, British Museum), from the submerged Wealden beds at Brook Point, Isle of Wight, shows that these vertebræ increase in height as they recede from the head.

* *Streptospondylus Cuvieri*, 'Ossemens Fossiles,' tom. cit., p. 308, pl. ccxxxvi.

In the present specimen the parapophysis is still developed from the side of the centrum and from its anterior half; but it expands more rapidly as it approaches the terminal ball, with which its own articular surface seems to be continuous. The side of the centrum behind the parapophysis is convex vertically at its upper half, slightly concave vertically as it descends to the thick inferior convex ridge, which is broadest behind, as in the more advanced and longer vertebræ.

The diapophysis is now supported by a thick, rounded prominence, beginning near the lower and hinder part of the neural arch, and, expanding as it rises, it advances to the base of the diapophysis; this is the beginning or rudiment of the hinder converging ridge in the type vertebra of *Streptospondylus*, as described and figured by Cuvier.*

The neural canal has the same shape and relative size as in the more advanced vertebra (Pl. 31, figs. 1, 2, and 3). The pedicles or bases of the neural arch present the same superior thickness, as compared with the *Iguanodon*, showing a convex, rounded border behind as well as in front. There is a median depression at the back part of the base of the neural spine.

The following are admeasurements of the bodies of the above-described three cervical and anterior dorsal vertebræ of the Wealden *Streptospondylus*:

	Tilgate.		*Culver Cliff.*		*Brook Point.*		*Dorsal.*	
	Inch.	Lines.	Inch.	Lines.	Inch.	Lines.	Inch.	Lines.
Transverse diameter of posterior concave articular surface	5	0	6	0	6	0	5	6
Vertical diameter of posterior concave articular surface	3	6	4	6	5	0	6	0
Antero-posterior diameter of entire vertebra .	6	0	5†	0	6	0	5	9
Transverse diameter of the body across the parapophyses	6	0	6	6	6	6	....	
Height from lower surface of centrum to the hind part of base of spine . . .	....		7	9	10	0	10	6
Antero-posterior extent of parapophysis . .	2	2	2	4	2	9	....	
Interspace between upper and lower transverse processes	....		2	0	2	9	....	

In the museum of the Geological Society of London there is a collection of rolled

* Loc. cit.

† It is evident that an inch at least, perhaps more, has been chiselled away from the ball which terminated the anterior end of the body of this specimen in Mr. Saull's collection.

vertebræ from the coast at Brook Point, Isle of Wight, which, among the bones of *Iguanodon* and other gigantic Wealden genera, contains the centrum or body of a dorsal vertebra of the great *Streptospondylus.* This specimen, though much rolled and worn, is interesting, inasmuch as it exhibits the characteristic contraction of the middle and expansion of the ends of the centrum, together with unequivocal evidences of the marked depression on each side, near the upper part of the anterior or convex end of the centrum. What remains of the depression is about the size of the end of a man's thumb. The convexity of the anterior extremity resembles in degree, and likewise in irregularity, that in the fractured vertebra of the *Streptospondylus* from the lower Oolite, in Mr. Kingdon's collection.

The present centrum is less depressed than those of the cervical region, but agrees with them in length, as the following dimensions show:

	Inch.	Lines.
Antero-posterior diameter	5*	0
Vertical diameter of concave end	5	6
Transverse diameter of concave end	5	3
Transverse diameter of middle of centrum	3	0

In Pl. 32, fig. 4, a reduced figure of two of the anterior (cervical?) vertebræ of the young *Iguanodon* from Cowleaze Chine, is reproduced to show the difference in the form of the angle between the ridges diverging from the neural spine to the posterior zygapophyses, and in the form of the ridges themselves, which are much sharper in *Iguanodon* than in *Streptospondylus major;* the degree of the terminal convexity and concavity of the centrum are both less marked in the *Iguanodon.*

Dorsal vertebra of Streptospondylus major. Plate 33.

I am now able to carry out the comparison of the Iguanodont and large Wealden Streptospondylian vertebræ at the part of the dorsal region where the parapophysis has passed from the centrum to the neural arch, and this is decisive against the ascription of the latter vertebræ to the *Iguanodon.*

That the dorsal vertebra, with a convexo-concave centrum, belongs to the same species as the cervical vertebræ here described and referred to *Streptospondylus major*, is shown by the same vertical contour of the sides of the centrum, convex at the upper and concave at the lower half, and by the shape of the thick, obtusely rounded, inferior median ridge, which still shows the triangular form with the posterior base, and is slightly convex lengthwise (fig. 3). In the corresponding vertebra of the *Iguanodon* the upper half of the side of the centrum is slightly concave vertically, and the lower

* The margins of the extremities being worn and rounded prevent the actual length being given.

half convex, the converging sides here terminating in a sharp ridge, which is concave lengthwise (fig. 6).

In *Streptospondylus major* the centrum loses in length and gains in height; the neural arch at the same time augmenting in height as the vertebræ recede from the neck. In the dorsal vertebra here described, there appears another Streptospondylian character, pointed out by Cuvier in the Harfleur gavial-like species, the support, viz., of the transverse process by ridges, converging to its base. The anterior ridge (ib., fig. 2, *a*) ascends almost vertically in front of the surface (*a*, fig. 2) for the head of the rib, the posterior ridge (*e*), forming the outer and back part of the neural arch, ascends obliquely forward to meet the first ridge beneath the diapophysis (*d*).

In the *Iguanodon* the first ridge (*a*, fig. 4) is hardly represented; the second (*e*) is well developed, but is nearly vertical. The chief difference, however, which the vertebræ here compared of *Iguanodon* and *Streptospondylus* present, is seen in the structure of the neural arch behind the posterior ridge.

In *Streptospondylus major* the surface of the neural arch is continued from the posterior ridge inwards and a little backwards, almost flat, to the thick, rounded border of the posterior aperture of the neural canal, expanding with a slight concavity to the base of the posterior zygapophysis. In *Iguanodon* the corresponding part of the neural arch, viz., behind the posterior ridge (fig. 5, *e*), is excavated by a large and deep cavity.

The neural canal in *Iguanodon* (fig. 5, *n*) is relatively smaller than in *Streptospondylus*, especially narrower, its area presenting the form of a vertical ellipse, whilst in *Streptospondylus* it is a wide transverse ellipse (fig. 1, *n*). In *Iguanodon* a ridge (*r* fig. 5), formed, as it were, by the lateral compression of the back part of the neural arch between the two large hollows behind the buttresses of the diapophyses, rises vertically to the median approximate extremities of the posterior zygapophyses (fig. 5, *z'*). A broad, vertically convex surface, holds the place of the above ridge in *Streptospondylus*. The forepart of the neural spine is thicker in *Streptospondylus* than in *Iguanodon*, and there is a deeper and more circumscribed cavity on each side of that part of the spine on the roof of the neural arch. The side walls of that arch are much thicker in *Streptospondylus*, especially anteriorly, and the arch is shorter in proportion to the centrum than in *Iguanodon*. With all these differences between answerable dorsal vertebræ of *Iguanodon* and *Streptospondylus*, there remains the capital one of the front ball and hind cup in the latter, where the corresponding surfaces are flat or very slightly depressed in the *Iguanodon*.

The determination of the true nature of the convexo-concave vertebræ of the Wealden, and of the affinities of the reptile to which they belonged, besides extending our knowledge of the gigantic oviparous animals of that epoch, removes one of the chief difficulties attending the determination of the true vertebral characters of the *Iguanodon*. For, if gigantic vertebræ, agreeing in the important character of their articular surfaces with the existing *Iguanæ*, had actually been discovered, though of

rare occurrence, associated with teeth of corresponding dimensions, but similar in form to those of the Iguana, there would have been strong ground for suspicion that such vertebræ and teeth might have been parts of the same species.

We now know, however, that certain of the cup-and-ball vertebræ are of a kind more nearly resembling those of an extinct Crocodilian, with teeth very different from either those of *Iguanodon* or of the modern diminutive *Iguanæ*. The elimination of these, otherwise perplexing ball and socket-jointed vertebræ, forms, therefore, an essential step in the appropriation to the *Iguanodon* of its proper vertebral type.

Genus—Cetiosaurus, *Owen*.

Species—Cetiosaurus brevis, *Owen*. Plates 23, 34, 35, 36.

In the notices of the various forms or types of vertebræ from the Wealden strata, published by their persevering investigator, Dr. Mantell, prior to 1841, he states* that "his first step was, with the able assistance of the Rev. W. D. Conybeare, to separate those that belonged to the Crocodile, Plesiosaur and Megalosaur, or at least the vertebræ which most resembled those from Stonesfield."

Many enormous vertebræ remained, which are referred, in the Mantellian Catalogue of the collection subsequently purchased for the British Museum, to the *Iguanodon*. From these residuary specimens I separated, in my 'Report on British Fossil Reptiles,' of 1841, the vertebræ characteristic of the genera *Poikilopleuron*, Deslong., *Streptospondylus*, v. Meyer, and *Cetiosaurus*, which latter genus had previously been characterised by vertebral peculiarities observed in specimens obtained from older Oolitic strata.

Of the existence of vertebræ of this genus in the Wealden strata, I first became acquainted by the examination of the late Mr. Saull's collection of sea-rolled fossils washed out of the submerged Wealden beds, and deposited on the shores of the Isle of Wight, at Sandover Bay.

The vertebræ in question presented the well-marked generic characters of those of the dorsal region in the *Cetiosaurus longus* of the middle Oolite, as, *e.g.*, the breadth of the centrum, its subcircular contour, its median contraction and unequal concavity of the articular extremities; as, also, the short antero-posterior extent of the neurapophyses and their anchylosis to the anterior part of the upper surface of the centrum: but they differed from the vertebræ on which the characters of the present

* 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 76; 'Geology of the South-east of England,' 8vo, 1833, p. 278.

genus were first founded* by the shortness of their antero-posterior diameter as compared with their breadth and depth, whence I proposed to designate the species by the name of *Cetiosaurus brevis*.†

The centrum of a dorsal vertebra of this species from Culver Cliff measures,

	Inch.	Lines.
in antero-posterior diameter	3	6
transverse diameter	6	4
vertical diameter	6	0

The hind articular end (Pl. 34, fig. 2, *b*) is moderately concave: the front end (ib., *a*) from the wearing away of the margins, appears slightly and unevenly convex. The contracted middle part of the vertebra is concave lengthwise, and pretty regularly convex in the direction transverse to the axis of the vertebra: the free surface is finely striated, and perforated here and there by vascular foramina: there is no lateral depression. The bases of the neurapophyses, instead of having their long diameter corresponding with the axis of the vertebra, as in *Iguanodon*, present it in the direction transverse to that axis, as in *Plesiosaurus:* they do not quite meet at the middle of the upper or neural surface of the centrum, but are there divided by a narrow longitudinal tract forming the lower part of the spinal canal. The antero-posterior extent of the anchylosed base of the neural arch (ib., *n*) is 2 inches 6 lines: the transverse diameter of the arch is 5 inches.

The caudal vertebræ of the same species, also from Culver Cliff, present the same length and unequal concavity of the articular extremities; the anterior one, here determinable by the anterior position of the narrower hæmapophyses, being the deepest: the sides of the body are more compressed, and more convergent towards the under surface; so that, as the expanded margins of the articular ends are worn away, the centrum presents rather a triangular than a subcircular contour. The disproportion of its antero-posterior with its transverse and vertical diameters, distinguishes it from the caudal vertebræ of the *Iguanodon*. The neurapophysis rises from the anterior three fourths of the centrum, and sends forward a subprismatic anterior oblique process, but does not develope a posterior one: it then contracts, and inclines to the base of the spine, which is much shorter than in the *Iguanodon*. The spinous process inclines backward from the vertical axis of the centrum at an angle of 45°. A short transverse process is developed from the junction of the neurapophysis with the centrum. The hæmapophysial surfaces appear single on both the anterior and posterior parts of the lower surface; they are nearly flat, and slope towards each other.

* See 'Proceedings of the Geological Society' for June, 1841.

† 'Report of British Fossil Reptilia,' 1841, 'Trans. Brit. Association,' p. 94.

The following are the dimensions of the best preserved of these vertebræ :

	Inch.	Lines.
Antero-posterior diameter of centrum	3	0
Transverse diameter	5	0
Vertical diameter	5	0
Height of vertebra to summit of spine*	12	9
Antero-posterior diameter of spine	2	10
Thickness at posterior part of base	1	0
Height of spine, 1st caudal	5	0
Height of spine, 2d caudal†	4	0

The characters and dimensions of these rolled vertebræ of *Cetiosaurus* from the submarine beds of the Wealden formation, although somewhat obscured by the circumstances under which they are brought to light, are sufficiently satisfactory to establish their generic character, and to give an useful approximative idea of their size and proportions. The corresponding bones from the Wealden of Tilgate Forest supply, by their more perfect state of preservation, the deficiencies of the Isle of Wight specimens, and further establish the co-existence of the *Cetiosaurus* with the *Iguanodon*, *Hylæosaurus*, *Streptospondylus*, *Megalosaurus*, and other extraordinary reptiles of that period. The vertebræ of the *Cetiosaurus brevis* in the Mantellian Collection are amongst the most gigantic specimens of Saurian remains that enrich it. They include almost entire specimens and bodies of two dorsal vertebræ (Pls. 34 and 35) and four entire caudal vertebræ (Pls. 23 and 36), which, if not consecutive, seem to have come not from distant parts of the basal portions of the tail of the same individual.

No. $\frac{133}{2153}$ "Gigantic vertebra of *Iguanodon*," MS. Catalogue of Mantellian Collection (Brit. Mus.), is a posterior dorsal vertebra of the *Cetiosaurus brevis*, and exhibits in a striking manner the peculiar characters of this species, viz., the great depth and breadth, especially the latter dimension (Pl. 34), as compared with the length or antero-posterior diameter (Pl. 35) of the centrum or body of the vertebra.

The posterior articular surface (Pl. 35, fig. 2, *b*) is, in this region of the spine, more concave than the anterior surface, a structure which approximates to that peculiar one which characterises the *Streptospondylus*. The contour of the articular ends is subcircular, the transverse diameter being somewhat in excess. The centrum is contracted between the two articular ends, is slightly concave in the longitudinal direction at the upper part of the side of the centrum, but deeply concave below, and with a slight indication of a broad, obtuse, longitudinal ridge (Pl. 35, fig. 1, *r*), along the middle of the concave under surface. In the *Iguanodon* the sides of the vertebral body are nearly flat in the vertical direction ; in the *Cetiosaurus* they are strongly convex. The surface at the middle of the vertebra is longitudinally striated

* This is rounded off, but seems not to have been broken.

† The 1st and 2d do not here refer to the place of these vertebræ in the tail ; but if the vertebræ were contiguous in the entire animal, the tail must be much shorter than in the *Iguanodon*.

with very fine, subparallel, short impressions ; these grow deeper and more irregular at the thick, rugged, and everted margins of the articular ends.

The neurapophyses are firmly anchylosed here, as in the caudal region, and the line of the primitive suture is hardly discernible : their base is shorter than the short centrum, and is attached nearer its anterior part ; in the *Iguanodon* the neural arch is very nearly coextensive in antero-posterior diameter with the centrum supporting it ; in a dorsal vertebra of an *Iguanodon* $4\frac{1}{2}$ inches in breadth, the antero-posterior extent of the base of the neural arch is 4 inches ; in the present vertebra, which exceeds 7 inches in breadth, the antero-posterior extent of the neural arch is $2\frac{1}{2}$ inches, and only 2 inches a little above the base. The outer side of the neurapophysis is convex in the axis of the vertebra, and concave in the opposite direction as it ascends to the base of the diapophysis, showing only the posterior of those ridges and hollows that so singularly characterise the same part in the dorsal vertebræ of *Streptospondylus Cuvieri*. The antero-posterior diameter of the base of the diapophysis is 2 inches, its vertical diameter 1 inch. The diameter of the neural canal (*n*) is 1 inch 9 lines. The articular surfaces of the anterior zygapophyses (Pl. 35, fig. 1, *z*) are flat, and look upward forward, and slightly inward. In the *Iguanodon*, their under margins, in the dorsal vertebræ, converge at nearly a right angle ; in the present vertebra they incline to each other at an angle of 40°. The spinous process begins to rise immediately behind the anterior zygapophyses by a narrow vertical plate, which seems as if it were nipped in between two shallow depressions ; its base ascends obliquely, and grows thicker to the posterior part of the neural arch. The summit was not entire in any of these vertebræ.

The height of this dorsal vertebra to the posterior origin of the spinous process is $9\frac{1}{2}$ inches ; from the base of the neurapophysis to the upper part of the transverse process, measures 3 inches.

No. $\frac{115}{2115}$ in the Mantellian Collection, British Museum ("Vertebra of *Iguanodon*, 8 inches in diameter," MS. Catalogue), may have actually presented that dimension when entire, for even now, not allowing for the margin of the posterior articular surface which has been broken away, it measures 7 inches across the surface. This remarkable specimen, which may probably have afforded the type of the "third or plano-concave" vertebral system, in the summary of the vertebral characters of the Wealden reptiles given by Dr. Mantell in his 'Geology of the South-east of England,'* and which accords best with the characters assigned by M. H. von Meyer to the vertebræ of the *Iguanodon*,† presents, in fact, in a striking degree, those of the vertebræ of the *Cetiosaurus*, and belongs to a more posterior part of the dorsal region, perhaps to the loins, of the same individual, certainly to one of the same species, as the vertebra (No. 2133) last described. A figure of a corresponding vertebra bisected vertically is given in Pl. 35, fig. 2.

* 8vo, 1833, p. 292, fig. 3.

† 'Palæologica,' p. 212.

The anterior articular extremity in one of these vertebræ makes an approach to a plane surface, being slightly concave transversely below, and very slightly convex above; vertically it is very slightly convex; the depth of the posterior concave surface at the centre is 9 lines. The general contour of the centrum has begun to change from the circular to the subquadrate, which latter figure is more decidedly expressed in the anterior caudal vertebræ of *Cetiosaurus brevis* (Pl. 36).

The upper half of the sides of the centrum are more concave in the axis of the vertebra than in No. 2133. The free surface presents the same degree of smoothness, and is pierced here and there by moderate-sized vascular foramina. The neural canal makes a slight depression in the upper part of the centrum; in the *Iguanodon* it is encompassed by the bases of the neurapophyses. The transverse diameter of the neural canal is 1 inch, which small dimension satisfactorily distinguishes the present enormous vertebra from those of the mammiferous class, viz., the Cetacea, to which in other respects it has the greatest similitude. The antero-posterior diameter of the base of the neurapophysis is 2 inches.

The four anterior caudal vertebræ in the Mantellian Collection, which are here assigned to *Cetiosaurus brevis*, Pl. 23, slightly increase in antero-posterior diameter, as is the case with *Cetiosaurus medius*, as they recede from the trunk, which seems to indicate that the present gigantic marine Saurian must have had a capacious and bulky trunk, but propelled by a longer and more crocodilian tail, than in the modern whales. It is sufficiently evident, however, that, even in the present short segment of the tail, with the slight increase of length, there is a diminution of height and breadth of the centrum, and a still more obvious subsidence of the neural arch, as the vertebræ recede from the trunk. The third of these vertebræ is figured of the natural size in Pl. 36. As compared with the dorsal vertebræ, the chief change of form is the subquadrate contour produced by a lateral extension and flattening of the lower surface of the centrum, which is more essentially distinguished by four hæmapophysial articular surfaces, two at the anterior and two at the posterior margins (Pl. 36, *h*, *h*) of this inferior surface. The articular surfaces at both ends of the centrum are now slightly concave; and the anterior one, which was nearly flat in the dorsals, is here the deepest; it is one inch deep at the upper third of the surface.* The sides of the centrum at the upper half are concave both lengthwise and vertically, forming a wide depression below the transverse process; the middle part of the side begins to stand out and divide the upper from the lower lateral concavity, which character, being more strongly developed in the hinder caudal vertebræ, gives the rhomboidal or hexagonal form.† The lower half of the side of

* The same modification of the articular extremities occurs in the caudal region of the vertebral column of the *Plesiosaurus*. See 'Report,' part i, 'Trans. Brit. Assoc.' 1839, p. 58.

† It is one of these posterior caudals of the *Cetiosaurus* which is figured as the type of the "second vertebral system" in the 'Geology of the South-east of England,' p. 296, fig. 2.

the centrum is less concave than in the dorsal vertebræ. The broad inferior surface is also less concave antero-posteriorly than in the dorsal vertebræ, and is nearly flat transversely; it gradually contracts, in the transverse direction, in the posterior caudals, so as to take on the form of a longitudinal sulcus. The two anterior hæmapophysial surfaces are separated from each other by an interval of two inches; the two posterior surfaces, which are larger than the anterior ones, are similarly distinct.

In the anterior as well as posterior caudal vertebræ of the *Iguanodon* the hæmapophysial surfaces are confluent on both the anterior and posterior parts of the under surface of the centrum, and the chevron bones accordingly present modifications by which they may, when detached, be distinguished from those of the *Cetiosaurus*. There was, however, as will be presently shown, another gigantic Saurian of the Wealden period, distinct from the *Cetiosaurus* and *Iguanodon*, but resembling the latter in the single hæmapophysial facet (Pl. 37).

The diapophyses, in the caudal vertebræ of *Cetiosaurus* (Pls. 23 and 36), have descended, as usual, from the summit to the base of the neural arch in the anterior caudal vertebræ. They are short, compressed vertically, diminishing, and as if slightly twisted, so that the upper margin is turned forward, at their extremity. The vertical diameter of the base of the transverse process in the largest of the present caudal vertebræ is 3 inches; its antero-posterior diameter is 1 inch 6 lines; its length is 2 inches 7 lines: the extremity terminates obtusely. The upper ridge-like termination of the transverse process is continued to the base of the anterior zygapophysis. These processes (ib., *z*) are alone developed, as such, in the present vertebræ; the posterior articular surfaces (Pl. 36, *z*) being impressed upon the sides of the posterior part of the base of the neural spine. The anterior zygapophyses project almost horizontally forward, diminishing, chiefly in vertical diameter, to an obtuse apex; convex externally, flattened internally by the oblong articular surface, and separated by a fissure nearly 1 inch wide: the length of these processes, from the bottom of the intervening fissure in the second of the four caudals, where they are most entire, is 2 inches. When the vertebræ are placed in juxtaposition, these processes reach beyond the middle of the vertebræ next in front, and pinch, as it were, the back part of the base of the spine so as to impress upon it the surfaces representing the posterior zygapophyses. These processes are well developed, on the contrary, in the corresponding vertebræ of the *Iguanodon*, and overhang the posterior surface of the body of the vertebra to which they belong. The spinous process, which appears to be nearly perfect in the second caudal, is short, strong, and truncated at the summit. Its height from the anterior oblique processes is 4 inches: the total height of the vertebra is 13 inches. The antero-posterior diameter of the side of the neural arch is 2 inches. The spinal canal is wider in these caudal than in the dorsal vertebræ, indicating the greater muscularity of the part deriving its nervous power from the corresponding part of the spinal cord: its transverse diameter is 1 inch

10 lines; its vertical diameter is 2 inches. The neural arch is, as usual in the present genus, anchylosed to the anterior part of the upper surface of the centrum: one inch and a half of this surface is left free behind the attachment of the arch. The finely wrinkled or fibrous character of the free surface is more strongly marked in these caudal than in the dorsal vertebræ.

In the three succeeding vertebræ the neural arch diminishes in height, the anterior articular processes diminish in length, and the posterior articular impressions in depth. The upper and lower parts of the sides of the body become somewhat more concave; the posterior articular surface grows flatter.

A detached chevron bone, 8 inches in length, consisting of two hæmapophyses, anchylosed only at their distal or inferior extremities, and with their distinct proximal ends more divaricated than are the confluent ones in the *Iguanodon*, corresponds with the caudal vertebræ here described, and doubtless belongs to the *Cetiosaurus brevis*.

The following are dimensions taken from the four caudal vertebræ above described:

	1st.		2d.		3d.		4th.	
	Inches.	Lines.	Inches.	Lines.	Inches.	Lines.	Inches.	Lines.
Antero-posterior diameter of centrum .	3	9	4	2	4	3	4	3
Transverse diameter of centrum . .	7	2	7	1	6	9	6	4
Vertical diameter of centrum . .	6	10	6	8	6	0	6	0

Of the present species of *Cetiosaurus*, I have examined specimens of the bodies of one dorsal and three posterior caudal vertebræ in the collection of Gilpin Gorst, Esq., which were obtained from the central strata of the Wealden, near Battle Abbey, commonly called the "Hastings beds."

The dorsal centrum closely agrees with those in the Mantellian Collection: its anterior surface is, as in them, nearly flat, or slightly convex; the posterior surface is concave.

	Inches.	Lines.
The antero-posterior diameter	3	2
The transverse diameter of the anterior surface	5	3
The vertical diameter of the anterior surface	5	2

The neurapophyses, with an antero-posterior extent of base of 2 inches 3 lines, are continuously anchylosed with the centrum, and leave about three quarters of an inch of the posterior part of the centrum free. The floor of the spinal canal is horizontal lengthwise; its transverse diameter 1 inch 3 lines.

The posterior caudal vertebræ present an antero-posterior diameter of nearly 4 inches, with a breadth of $3\frac{1}{2}$ inches, and a depth of 4 inches, measuring to the lower part of the posterior hæmapophysial surface. The antero-posterior length

of the base of the neurapophysis is 2 inches 2 lines; and it does not begin so close to the anterior part of the centrum as in the dorsal vertebra. There are no posterior zygapophyses. The upper and lower portions of the side of the centrum are more distinctly separated by the comparative projection of the middle part, which gives the obscurely hexagonal form to these vertebræ. The inferior parts are most concave, and converge to form the sides of the longitudinal sulcus, to which the inferior surface of the centrum is reduced at this part of the tail. It is plain, from these modifications of the vertebræ, that the tail must here have presented the compressed Crocodilian type; and it is satisfactory to have these indications of the Saurian affinities of the present gigantic fossil, in consequence of the very close approximation of the larger vertebræ to the Cetaceous type. The vertical extent of the osseous basis of the tail was here augmented by strong hæmapophyses, which have left more prominent articular facets on the under part of the centrum than in the larger anterior caudal vertebræ: these facets, instead of being in pairs, as in the anterior caudals, approximate, and become confluent in the vertebræ of between 3 and 4 inches in breadth.

Occasionally the hæmal arch is found anchylosed to the posterior of these so confluent hæmapophysial surfaces, as in the posterior caudal vertebra figured in Pl. 31, figs. 3 and 4.

A vertical section, through the middle of a dorsal vertebra, from that part of the back where the rib has ascended to articulate wholly with the diapophysis, well displays this characteristic modification of the articular parts of the centrum, in *Cetiosaurus* (Pl. 35, fig. 2). The same section shows the closer cancellous texture of the centrum near those articular ends; the more open texture, with a general tendency to a longitudinal course of the cancelli, in the middle; and the still more open and irregularly disposed cancellous structure at the base and back part of the neural spine.

From the foregoing data it may be inferred that there existed, at the period of the deposition of the Wealden, a Saurian reptile of dimensions at least equalling those of the *Iguanodon*, but with modifications of the vertebral column, from the middle of the back to the tail, departing from the Dinosaurian and approaching to the Crocodilian type. If, as is very probable, the cervical and anterior dorsal vertebræ above described (pp. 400—404, and provisionally referred to *Streptospondylus*), belong to the same reptile as the succeeding vertebræ, here referred to *Cetiosaurus*, we should then have a gigantic Crocodilian of the peculiar transitional type, as between that order and the Dinosaurian, which is manifested by the second "Honfleur Gavial" of Cuvier; *i. e.*, with convexo-concave vertebræ at the fore part of the trunk, graduating into plano-subconcave vertebræ, with elevated and somewhat complex neural arches, at the middle and back part of the trunk, and with vertebræ subconcave at both ends, in the tail.

Of the nature of the sacrum and pelvis in the present genus nothing definite and assured is at present known. Such proportions of the entire skeleton of one and the same individual as have imparted our present knowledge of the *Iguanodon* and *Megalosaur*, have not yet been discovered of the *Cetiosaurus*. Certain co-existences in relation to strata and localities, but hardly amounting to juxtaposition, indicated that the tibia and some other limb-bones of the Reptile with Cetiosaurian vertebræ were without a medullary cavity, and with the centre occupied by a coarse cancellous tissue.*

At the period when the vertebræ of this type were first discriminated from the veritable ones of the *Iguanodon*, I had not met with this characteristic structure of Cetiosaurian limb-bones in strata above the Portland Stone (Middle Oolite). They have since been found in the Wealden strata.

The late Dr. Mantell, in his Memoir on the *Pelorosaurus*, states: "I have a series of bones from Brook, in the Isle of Wight, through the kindness of my distinguished friend, Sir R. I. Murchison, proving the existence of *Cetiosauri* in the Wealden; all the long bones are destitute of a medullary cavity."†

A somewhat crushed femur of *Cetiosaurus longus*, measuring 4 feet 3 inches in length, from the Middle Oolite at Enslow Bridge, Oxfordshire, is preserved in the Geological Museum at Oxford: it does not show any medullary cavity. The specimens of Cetiosaurian long bones, from Wealden strata, which have hitherto come under my observation, are fragmentary. It is probable that parts of the coracoid and pubic bones, also from the Wealden, indicating a greater relative breadth of those elements of scapular and pelvic arches, than in true *Crocodilia*, but differing in form from the answerable bones in known *Dinosauria*, may have belonged to *Cetiosaurus brevis*, Ow.

The suppression of the species so named by me has been proposed, and its appropriation by another has been attempted,‡ under the name of *Cetiosaurus Conybeari*, Melville, "in order to prevent confusion and to remove the objection that may well be raised against the *nomen triviale* '*brevis*;'" "for who will venture," asks the appropriator, "to indicate the relative length of an animal with no known affine, from four of its anterior caudal vertebræ?"

Believing that the generic affinity of the *Cetiosaurus brevis* with *Cetiosaurus longus* and *Cetiosaurus medius* to have been demonstrated, I ventured to suggest, in 1841, that the *nomen triviale* might be found appropriate in reference to the relative length of the entire body, from what was then known "of the constancy and regularity of this dimension" (viz., length of vertebral centrum) "in the back bone of

* 'Report on British Fossil Reptiles,' 1841, p. 102.

† 'Philosophical Transactions,' 1850, p. 381.

‡ Ibid., 1849, p. 297.

individuals of the same species of Saurian." Subsequent experience of this constancy in the dorso-lumbar and caudal regions of the spine in *Crocodilia* and *Dinosauria* has confirmed me in that opinion. But I expressly stated, when proposing the specific names of the different species of *Cetiosaurus*, that those names referred "to the relative length of their vertebræ."* The highest authorities in palæontology had sanctioned this system of naming species from characters of instructive parts. And no naturalist appears to have supposed that the *Palæotherium latum* of Cuvier had necessarily a trunk as broad in proportion as the foot, or that the whole frame of *Anoplotherium obliquum* was askew. The *Raia spiralis* of Münster was not a twisted Skate, any more than the *Otodus ramosus* of Agassiz was a branched Shark. As to the plea of preventing confusion by changing the published name of an adequately defined species, competent naturalists concur in denouncing the practice, as being the chief cause of the present grievous confusion in zoological synonymy.

The objections to the species *Cetiosaurus brevis*, and a subsequent attempt to suppress the genus, call for notice here on account of their admission into volumes of so high a scientific repute as the 'Transactions of the Royal Society.' The reporters on the papers by Drs. Melville and Mantell must have assigned some value to the remarks which here receive the explanation from the author against whom they were directed.

Genus—Pelorosaurus, *Mantell.* Plates 37 and 38.

When publishing condensed descriptions of the previously undescribed, and for the most part undetermined, fossil remains of *Reptilia*, in my 'Reports' on that class submitted to the British Association in 1840 and 1841, it was known that the drawings made by aid of the grant voted for that purpose by the Association would subsequently be published in the work or monographs containing the more complete History of those British Fossil Reptiles. Reduced figures of the vertebræ, ascribed to *Cetiosaurus brevis*, and described in pp. 95—100 of the 'Report' of 1841, were, however, published, by anticipation, in the 'Philosophical Transactions' for 1850; the author quoting a remark by Sir J. G. Dalyell, that "delineation should be the inseparable accompaniment of description in natural history" (tom. cit., p. 382), and citing the descriptions in detail of these vertebræ, given "by Dr. Melville, in the 'Philosophical Transactions,' 1849, p. 296."

* Report, 'Trans. Brit. Assoc.,' 1841, p. 102.

On referring to that volume and page, however, I find the description limited to a partial quotation from my 'Report,' with the acknowledgment that "the four huge caudal vertebræ already mentioned as assigned to the *Cetiosaurus brevis*, exhibit very peculiar characters, fully detailed by Professor Owen."

The only objection offered by Dr. Melville is to the "nomen triviale" of the species to which they were assigned, and to which objection the reply has been given above. The subsequent proposal to suppress the "nomen genericum" was made under the following circumstances. In 1847 there was discovered, in the Wealden of Tilgate Forest, Sussex, the limb-bone, measuring 4 feet 6 inches in length, (Pl. 38 of the present work) regarded as a "humerus" by Dr. Mantell, and, on account of its difference of form from that bone in the *Crocodiles*, *Iguanodon*, and *Hylæosaurus*, and its large medullary cavity, referred to a genus distinct from all then known Wealden Saurians under the name of *Pelorosaurus*.*

This unique fossil bone, of truly extraordinary size viewed as a humerus, was obtained by purchase, for the British Museum, after the demise of Dr. Mantell; and with it a number of large vertebræ, most of them from the caudal region, marked *Pelorosaurus*, were purchased at the same sale.

These vertebræ, now bearing the Museum numbers 28.627, 28.633, 28.634, 28.635, 28.653, 28.654, 28.655, 28.656, 28.657, correspond in colour and mineralized condition with the large, hollow long-bone. The original Mantellian labels, in the same handwriting, ascribing them to *Pelorosaurus*, have been scrupulously preserved, as they were attached to the specimens. It may, therefore, be inferred that they belonged, in the opinion of Dr. Mantell, to the genus and species which he proposed in the 'Philosophical Transactions' for 1850. Accordingly, the best preserved of these vertebræ is here figured, of the natural size, in Pl. 37, as the type of the anterior caudal vertebræ of *Pelorosaurus*, and the foregoing details are given in support of this ascription; because, singular as it may appear, not any of the vertebræ, marked *Pelorosaurus*, and preserved by Mantell, with the enormous limb-bone, in his private museum, as long as he lived, are figured, described, or even alluded to in his memoir on that genus; whilst he assigns to the base of the tail of his *Pelorosaurus*, the four vertebræ (Plates 23 and 36 of the present work) which were obtained by the British Museum, in the purchase of the first Mantellian Collection, in 1839, which were entered as vertebræ of the *Iguanodon* in the catalogue then prepared by the vendor, and on which I founded, in 1841, the species of *Cetiosaurus*, distinguished as *brevis*, from the longer Cetiosaurian vertebræ of older Oolitic strata.

A glance at the vertebræ figured of the natural size, and from the same

* Πέλωρ, monster, σαυρος, lizard.

aspect, in Plates 36 and 37 of the present History, will suffice to satisfy even a superficial comparative osteologist that they must belong to different species, if not genera, of Saurians. They are both from that anterior part of the tail where the vertebræ still retain the zygapophyses and send off the transverse processes (dia-pleur-apophyses, *d-pl*) from the base of the neural arch at its junction with the centrum: they are nearly, if not quite, homologous vertebræ. If No. 28.633 (Pl. 37) belonged, as its original possessor had marked it, to his genus *Pelorosaurus*,—No. 10.390 (Pl. 36) of the earlier collection of fossils, originally marked *Iguanodon*, could not belong to the same genus.

It will be presently shown that the caudal vertebra (Pl. 37) marked *Pelorosaurus* by Mantell in his latest collection of fossils, although much more like the corresponding vertebra of *Iguanodon* than is the vertebra (Pl. 36) so called in the first Mantellian collection, yet presents such differences as might have justified a generic separation from *Iguanodon*, if even the indication of the distinct genus of huge Wealden Saurian had not been afforded by the hollow limb-bone of $4\frac{1}{2}$ feet in length.

The generic distinction of the above-cited vertebra from the first collection (Pl. 36), selected by Mantell, in his memoir of 1850, to illustrate the vertebral characters of the new genus *Pelorosaurus*, founded on the later acquired fossil limb-bone, is much more strongly marked as compared with *Iguanodon*, or with the anterior caudals marked *Pelorosaurus* in the last collection.

In 1850, therefore, the persevering investigator of the geology of the South-East of England had evidence of two gigantic genera of Wealden *Reptilia* distinct from his *Iguanodon*, afforded by vertebræ, and he possessed also similar evidence afforded by bones of the limbs.

Those of the latter which were destitute of a medullary cavity he unhesitatingly referred to my genus *Cetiosaurus*, and he founded upon the long-bone with the medullary cavity the genus *Pelorosaurus;* but, with respect to the vertebræ, he chose to select for the *Pelorosaurus* those that had been previously demonstrated by me to present the Cetiosaurian character.

Pelorosaurus Conybearii.

The anterior caudal vertebra (Pl. 37) differs from the corresponding vertebræ of *Iguanodon*, and is here referred to *Pelorosaurus*, on the authority of the Mantellian label, according to which it was purchased as belonging to that genus, and is so entered in the Register of the British Museum, under the number 28.633.

It presents the following dimensions:

	Inches.	Lines.
Antero-posterior diameter of centrum	4	0
Transverse diameter of centrum	7	9
Vertical diameter of centrum	8	9
Height of vertebra to summit of neural spine*	24	0
Antero-posterior diameter of spine	4	3
Thickness at posterior part of base	1	9
Height of neural spine	13	6

From these dimensions it will be seen that the vertebra of *Pelorosaurus* is shorter in proportion to its breadth than in the *Iguanodon;* in that respect resembling *Cetiosaurus:* the sides of the centrum are more concave lengthwise and less flattened vertically than in the basal tail-vertebræ of *Iguanodon.* Both the articular ends of the centrum are more deeply cupped. The neural spine is thicker and relatively shorter than in *Iguanodon,* but much longer than in *Cetiosaurus;* whilst the neural canal is more contracted than in either of those genera.

The anterior caudal vertebræ of *Pelorosaurus* differ from those of *Cetiosaurus* in the readily recognisable character of the singleness of the hæmapophysial surface (Pl. 37, *h*), and in this particular they resemble those of *Iguanodon.* As in the anterior caudals of that genus, also, the surface is much less marked at the fore than at the back part of the centrum. There is no longitudinal fossa connecting them (as in Pl. 14, *Dinosauria*): but this character is not common to all the caudal vertebræ in *Iguanodon.*

Humerus. Pl. 38.

The limb-bone, four feet and a half in length, discovered in 1847 by Mr. Peter Fuller, in the Wealden sandstone of Tilgate Forest, Sussex, so far as its extremities can be judged of in their present mutilated state, bears a closer resemblance to the right humerus of the Crocodiles and Alligators than to any other long-bone of known *Reptilia.* But were the wanting parts, of the proximal end more especially, to be such as to cause a closer resemblance to that end of the femur in *Iguanodon* or *Megalosaurus* than at present appears, the process *d* (Pl. 38, fig. 2), which, on the humeral determination, is the deltoid ridge, would answer to the inner trochanter (*d*), in the femur of the above-named *Dinosaurs* (Pl. 20, *Dinosauria*), a process which is wanting in the Crocodilian femur. I incline, however, to believe in the determination of this bone, adopted by the authors of the Memoir on

* From a contiguous vertebra of similar size, from the same collection and series, equally marked *Pelorosaurus,* and with the neural spine entire.

the *Pelorosaurus*, in the 'Transactions of the Royal Society' for 1850; but, unfortunately, the mistake of the anterior for the posterior surface of the bone—viewed as a humerus—in that memoir, vitiates the description, and must have added to the difficulty of comprehending, and to the doubts respecting, the nature of the bone, felt by the anatomists acquainted with it only by the figures and text in the 'Philosophical Transactions.' It may be that some transposition and misarticulation of the skeleton of the Gavial, in the museum of the eminent physiologist, whose aid Dr. Mantell acknowledges, occasioned the mistake. According to the analogy of the humerus of the Crocodile, the posterior contour of the shaft of the bone is concave above, convex below; but in a less degree in the *Pelorosaurus*. This longitudinal concavity would, however, be more marked in the specimen had the posterior part of the head (wanting at *a*, figs. 2 and 3) been preserved, and had the three pieces in which this half of the shaft was extracted from the matrix been a little more naturally joined together. The proximal end of the bone is transversely oblong, moderately convex, with both anterior and posterior borders broken away, but leaving the latter more prominent and convex. The internal angle or tuberosity (*i*), which, if entire, would have confirmed so satisfactorily the determination adopted, is also broken away. A still larger proportion of the external side of the proximal end is wanting, leaving only the lower end of the deltoidal ridge (fig. 2, *d*). This, however, reaches three sevenths of the way down the bone, but subsides, and probably begins, nearer the proximal end of the humerus than in the Crocodiles. It projects forward, and bears the same relative position to the fore and outer parts of the bone in *Pelorosaurus* as in *Crocodilia*. The transverse concavity on the inner side of the deltoidal process is continued lower down upon the shaft of the bone of the *Pelorosaurus*, which shaft is more compressed from before backward, giving a longer and narrower sub-elliptical section (Pl. 38, fig. 4) than in the *Crocodilia*. Below the middle the shaft gradually expands to the distal end, the condyles of which project chiefly from the fore part of the bone, as in the Crocodile: they are, however, more unequally developed, the outer one (figs. 2 and 5, *c*) being much the largest.* There is an indication of a low ridge diverging to the outer and fore part of the outer condyle, as in the Crocodile.

At the back part of the humerus of the *Pelorosaurus*, the upper half shows a minor degree of longitudinal concavity, and a lower and more regular transverse convexity, than in the Crocodiles. There is a foramen for the medullary artery at the middle of the back of the shaft, where I have observed it in some *Crocodilia* (e. g. *Croc. Hastingsiæ*). At the lower half the surface, instead of being flat, is transversely concave at the middle, or more concave and with such channel more longitudinally extended, than in *Crocodilia*. The depth has been increased

* This character is rather exaggerated in fig. 2.

at one part by pressure. The medullary cavity of the bone is well marked, and bears to the compact wall the proportion shown in fig. 4, Pl. 38.

From the foregoing scanty data relative to the *Pelorosaurus*, and on the supposition of the long-bone being, as I believe it to be, a humerus, it may be inferred that there coexisted at the Wealden period, with the *Iguanodon*, *Megalosaurus*, and *Hylæosaurus*, a reptile of more Crocodilian affinities, and of a bulk at least equalling that of the largest of these *Dinosauria*.

In the characters of the best-preserved vertebræ—those, viz., from the base of the tail,—the *Pelorosaurus* most resembles the *Iguanodon;* and the differences here observable may not be of more than specific importance: the Crocodilian character of the humerus points, however, to a generic distinction.

From the *Cetiosaurus* the *Pelorosaurus* is more obviously and decidedly distinct, by vertebral characters, which, in regard to the latter genus, have now been, for the first time, pointed out.

The genera of Saurian reptiles, hitherto determined, from the Wealden strata, have been founded on vertebral characters. With these, in regard to two of the genera, viz., *Iguanodon* and *Megalosaurus*, corresponding generic distinctions have been yielded by the teeth. The same may be affirmed, with a high degree of probability, but not as yet with certainty, in respect of the *Hylæosaurus*. There is a fourth form of tooth, generically distinct from the foregoing, applicable in respect of size to either *Cetiosaurus* or *Pelorosaurus*.

Not any of the foregoing genera have been founded on the structure of the limb-bones; for, indeed, such structure is not generic. Some of these bones, for example, may be hollow, and others solid in the same limb of the same reptile. The femur of the *Cetiosaurus* might have a small medullary cavity, whilst the tibia, the fibula, and the metatarsal were cancellous in the centre. The generic distinction of this huge reptile was originally, and in every subsequent descriptions of its specifically differing remains, founded upon vertebral characters. The names of the species bear reference to the proportions and minor modifications of essentially Cetiosaurian vertebræ. If, therefore, the long-bone—most probably humerus—above described, should belong to the same species as the *Cetiosaurus brevis*, and not to the very distinct species established in the vertebræ marked *Pelorosaurus* by Dr. Mantell in his last collection, the medullary cavity of the Crocodilian bone would be no sufficient ground for suppressing the genus.

Neither, supposing the appearance of the cancellous centre of the equally long limb-bone of the great Saurian from the Bradford Clay at Enslow Bridge, Oxfordshire, to be due to compression, obliterating the medullary cavity, would that afford just and satisfactory ground for determining the genus of reptile to which the crushed bone belonged. The tibia of the correspondingly large reptile from the same formation and locality, originally deemed to be Cetacean, is, indeed, solid; but

it might have coexisted with a femur in which a small medullary cavity had been established. Compression proves nothing, however, as against the cancellous tissue of the centre of a bone: the force that would squeeze the medullary shaft of a Crocodilian femur 4 feet long, to a thickness of 3 or 4 inches, would overcome any resistance that the loose spongy texture of a Cetiosaurian bone would offer. Moreover, the shorter diameter of the humerus, referred by Dr. Mantell to *Pelorosaurus*, is but $4\frac{1}{2}$ inches; and the medullary cavity there, is most patent and perfect: such a cavity could scarcely have escaped the notice of so close an observer as the late Mr. Hugh Strickland, if it had really existed in the long-bone from Enslow Bridge, now in the Geological Museum at Oxford, and referred to the genus *Cetiosaurus.*

The satisfactory proof of the existence of remains of a huge species of Wealden Saurian distinct from *Iguanodon*, *Hylæosaurus*, *Megalosaurus*, and *Cetiosaurus*, is afforded by the vertebræ, one of which is figured, of the natural size, in Pl. 37. For this genus and species the name of *Pelorosaurus Conybearii*, may be most conveniently retained: most properly so, indeed, if ulterior discoveries should prove the hollow humerus to belong to a reptile with the Pelorosaurian type of vertebra.

In the descriptions of the vertebræ from the Wealden given in my 'Report' of 1841, and in the figures of them now published, the foundations, at least, may be laid for rightly reconstructing the huge and strange Reptilia to which they severally belonged.

Tooth of a large carnivorous Wealden Reptile.

A fossil tooth of a large reptile was discovered, some years ago, in the Wealden Clay of Brixton Bay, Isle of Wight, which differs from the similarly sized teeth of *Iguanodon* and *Megalosaurus*, and, therefore, most probably belongs to either the *Cetio-* or *Peloro-saurus.*

The crown of this tooth, measured along the greatest extent of enamel, is 2 inches: about 1 inch and 5 lines of the fang is continued beyond the crown. The fang is subcylindrical at its broken base, becomes compressed as it approaches the crown, and this expands, with a diminution of thickness, as it extends from the fang, for about one third of the length, where two opposite trenchant margins begin; after which it gradually contracts to a point.

The extreme breadth of the crown measures 1 inch; the thickness is 8 lines. On one side (cut *b*) the crown is unequally convex; on the opposite side (cut *b*), at the apical two thirds, it becomes a little concave: one margin is gently convex,

the other is very slightly concave at the apical half. The convex side of the crown is covered by smooth enamel, which forms four low ridges on its most prominent part, and terminates inferiorly, by a delicate rugous structure, in a well-defined border, concave toward the root. The opposite side of the crown, flattened below and concave above, has the enamel smooth, except at the base, where it is rugous, and is extended nearly half an inch lower down the crown, where it terminates by a border convex toward the root.

The margins of the crown are obliquely abraded toward the concave side of the crown, and, near the base of the straighter border, there is an oblique depression.

The root is subcylindrical, and shows the remains of a pulp-cavity: it appears as if it had been implanted in a complete alveolar cavity; but the unequal extent of the enamel on the two sides of the crown indicates a corresponding inequality in the outer and inner alveolar walls of the jaw which supported this tooth. Assuming the thecodont mode of its implantation, it would in this respect resemble the teeth of the Crocodiles, and of certain Enaliosaurs and Dinosaurs.

The shape of the crown of this tooth, especially the degree of compression of the crown (cut *c*) and its expansion above the root into opposite borders, which become trenchant, accords best with the characters of the teeth in the carnivorous Sauria. Of such teeth as have hitherto been discovered in the Wealden strata, those that have been referred to the *Hylæosaurus** make the nearest approach to the form of the tooth in question; but, besides the difference of size, the crown has a more symmetrical shape in *Hylæosaurus,* and its broadest part is nearer the apex: the opposite worn margins which converge to the tip are both relatively shorter and thicker, and are not obliquely abraded so as to be trenchant, as they are in the larger Wealden tooth here described. It is a tooth of allied form to that of the *Hylæosaurus*, and, like it, was implanted by a cylindrical fang, apparently in a distinct socket: the few specimens that have been discovered of the teeth ascribed to *Hylæosaurus* appear to have been broken from the socket, not to have been naturally shed so as to show the traces of absorption; and the same is the case with the larger tooth in question.

The difference of form between the tooth of the *Megalosaurus* † and the present large piercing and cutting tooth is too obvious and strongly marked to need particularising; and it departs still further, both in shape and mode of implantation, from the tooth of the Iguanodon.‡

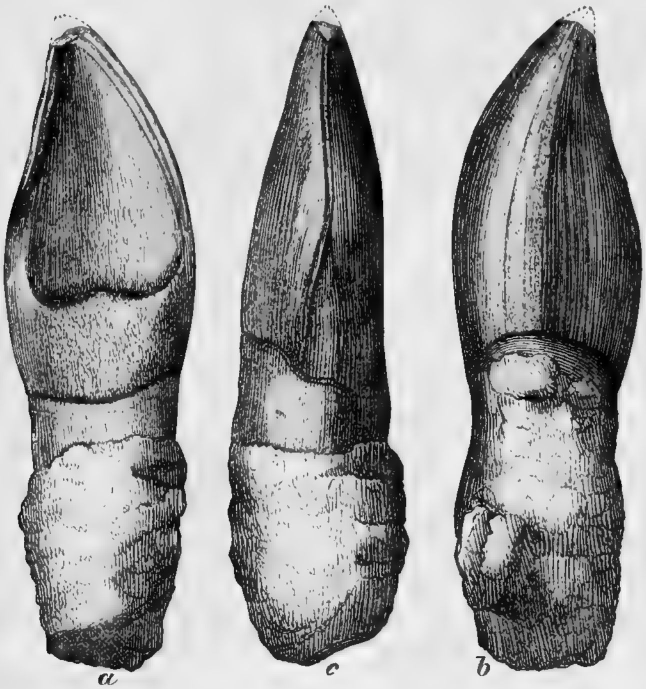
The present tooth, therefore, indicates a reptile equal in size to any of those above cited from the Wealden strata, but of a distinct genus: and vertebral evidence has been adduced, in the present 'Monograph,' of at least two genera—independently of

* "*Dinosauria,*" Plate 39, figs. 6—9.

† Ibid., Plates 33 and 34.

‡ Ibid., Plate 23.

Streptospondylus—of large Wealden reptiles equally distinct from those originally made known by Buckland and Mantell.



Tooth of large Wealden Reptile.—*Cetiosaurus* or *Pelorosauros* (?).

The tooth in question may, very probably, belong to either *Cetiosaurus* or *Pelorosaurus*. Future discoveries of teeth or of jaws with teeth, associated with the characteristic vertebræ of one or other of these large reptiles, will determine this question.

The tooth here described was first made known to geologists, and figured by Dr. Thomas Wright, F.G.S., an indefatigable explorer of the geology and fossils of the Isle of Wight, in a paper on the Palæontology of the Island, in the 'Annals and Magazine of Natural History' for August, 1852.

Genus—Poikilopleuron. *Eudes-Deslongchamps.*

This genus was first proposed, under the above name, by the accomplished Professor of Natural History in the Lyceum or University of Caen, Normandy, in his description of portions of a fossil skeleton of a Crocodilian reptile discovered in the oolitic quarries near that town. This reptile was distinguished from the ***Cetiosaurus*** by the more complete protection afforded to the abdominal cavity through the greater development of the posterior ribs, and, as the author then believed, by the greater diversity of form presented by the whole series of ribs, a peculiarity which suggested the generic name.* Perhaps the most truly distinctive character of this genus, so far as its organization is known, is the texture of the bones, and especially of the vertebral centrums, which show unusually large cavities in their substance, with a very compact outer crust, polished externally, and recalling the character of the skeleton in the ***Pterosauria***. It is this character which has led me to conclude that a species of the genus ***Poikilopleuron*** has left its remains in the formations of the Wealden period.

* Ποικίλος, *varied ;* πλευρον, *rib.*

VERTEBRÆ OF POIKILOPLEURON. '*Crocodilia,*' Plates 6, 19.

In the Museum of the Royal College of Surgeons, London, is a portion of a caudal vertebra (No 59 of the 'Fossil Reptilia,' Pl. 6, figs. 5, 6), presented by me, and obtained from the submerged Wealden beds at Brook Point, Isle of Wight.* The terminal articular surface (fig. 5) is elliptical, with the long diameter vertical, and is slightly concave; the middle of the centrum is contracted; the fractured surface (fig. 6) exposes a medullary cavity, surrounded by large, cancellous vacuities, which have become filled with siliceous spar and pyritic matter. There is a small depression on each side near the base of the neural arch, which seems to lead, like a pneumatic foramen, into the cavities of the bone. The thin, outer wall of this open, cancellous structure consists of very compact bone. This vertebra agrees in shape and structure with those of *Poikilopleuron.*

To the genus *Poikilopleuron* it is most probable that the specimen No. $\frac{141}{2141}$ in the Mantellian Collection, British Museum, belongs, as it agrees in size, in texture, and especially in the character of the external surface, with the caudal vertebra above described. As it consists of the annular part or neural arch only, the test of the medullary cavity of the body cannot be applied. It belongs to one of the anterior dorsal vertebræ, and is distinguished by well-marked and peculiar characters from the corresponding vertebræ of the *Iguanodon, Megalosaurus, Hylæosaurus, Cetiosaurus,* and *Streptospondylus;* and in the chief of these differences it approximates to the sub-biconcave Crocodilian type of vertebræ. By the characters here given of this fragment it may be compared with more perfect vertebræ from the Oolite of Maladrerie, near Caen, in the event of the remainder of the vertebral column of the *Poikilopleuron* ever falling into the hands of its original discoverer.

The present fossil is imbedded in the ferruginous sand of the Tilgate strata; its antero-posterior diameter, from the extremity of the anterior to that of the posterior zygapophysis, is 5 inches 4 lines.

The neurapophyses (Pl. 19, figs. 1 and 2, *d*) instead of rising and expanding to form a broad platform, as in the *Dinosaurian* vertebræ, support the spinous (fig. 4, *e*) and transverse (*e'*) processes by a longitudinal plate not more than from 3 to 6 lines in transverse thickness; from each side of this plate a horizontal, flat, broad, lamelliform diapophysis (*c*), supported below by a subvertical, triangular plate, extends outward and a little upward; and a broad, thin, and moderately high spinous process arises, in a peculiar manner, by two laminæ, from the whole antero-posterior extent of the ridge-like summit of the neural arch. The fossil is broken in two; a portion of the centrum adheres to the anterior part of the neural arch, demonstrating the anchylosis of the two parts without trace of suture. In this respect the fossil

* 'Catalogue of Fossil Reptiles and Fishes,' 4to, London, 1854, p. 15

agrees with *Poikilopleuron* and differs from *Iguanodon*, in which the neural arch is anchylosed with the centrum, but evident traces of the suture remain, at least in the dorsal vertebræ. The anterior part of the side of the centrum is impressed by a large surface for the head of the rib; the surface is concave in the axis of the vertebra, convex vertically, and is bounded above by a well-defined ridge.

The anterior zygapophysis (figs. 1 and 2, *a*) supports flat, articular surfaces, of an elliptical form, 16 lines by 9 lines, looking upward and inward; the lower edges of the pair of surfaces converging at an angle of 50°. These edges are separated from each other by a fissure $3\frac{1}{2}$ lines broad, continued to the base of the anterior oblique processes. In the *Iguanodon* the corresponding surfaces incline to each other at a right angle, and the lower margins of the processes are united by a continuous tract of bone. Each anterior articular surface is supported by a stout process, convex externally, inclining forward and slightly expanding, so as to overhang and extend beyond the anterior end of the centrum. A deep and narrow excavation commences immediately behind the upper and posterior origins of the anterior zygopophyses, and is continued backward, increasing in vertical extent, deep into the anterior part of the base of the spinous process. Immediately behind the columnar portion of the zygapophysis a conical cavity sinks into the neurapophysis, undermining the anterior part of the base of the diapophysis, and dividing the zygapophysis from it.

The diapophysis commences from the summit of the neurapophysis immediately exterior to the anterior part of the base of the spinous process, by a ridge which is continued backward from the upper and outer margin of the anterior zygopophysis, in a gentle curve outwards and slightly upwards. The posterior margin of the base of the diapophysis is not continued, in like manner, into the posterior zygapophysis, but terminates or subsides into a ridge above, and separated from that process by a wide groove.

The bases of the two diapophyses are only separated from each other, owing to the modification of the neural arch above mentioned, by a thickness of bone not exceeding 4 lines; the interspace of the origins of the two diapophyses in a corresponding vertebra of the *Iguanodon* measures 4 inches; the length of the base of the neural arch being the same in the vertebra compared.

The antero-posterior extent of the base of the diapophysis in this (presumed) vertebra of the *Poikilopleuron* is 2 inches 2 lines; the length of the diapophysis is 4 inches; the vertical diameter, or thickness of the same process, where unsupported, is from 2 to 3 lines. It is obvious, therefore, that this long, thin, lamelliform plate of bone must need further support, in order to sustain the rib which is appended by its tubercle to the extremity; and the requisite strength is here given precisely as the carpenter supports a shelf by a bracket. The bracket-like process (fig. 5, *c*) is a vertical, triangular plate of bone, the breadth or depth of which, at its origin, is 1 inch 4 lines; this gradually diminishes in depth and increases in thickness as it

extends along the middle of the under part of the transverse process, until it is finally lost near the extremity of the process, which here has exchanged its lamellar for a prismatic form, terminating in the obtuse extremity against which the tubercle of the rib abutted. The supporting bracket is not quite vertical, but inclines a little forward, and behind it there is a deep, angular fossa. The posterior zygapophyses (figs. 4, 5, *b*, *b*) diverge from each other and from the neural arch immediately above the posterior extremity of the spinal canal ; each articular surface, which is directed downward and outward, forms, as it were, the base of a posterior root of the spinous process, which is convex externally, diminishing in breadth as it converges to meet its fellow at a very acute angle above a deep fissure extending forwards into the substance of the base of the spine, similarly to the fissure before described as extending backward from the opposite part of the spine into its substance. As far as I could detach the matrix, these fissures extended so that they seem to communicate, and the neural arch to be perforated by two longitudinal passages, one for the spinal cord, and the other, running above and parallel with the former, through the base of the spinous process.

The anterior parts of each spinal plate are thickened and rounded, like those behind, and extend to the origins of the anterior zygapophyses. The diameter of this remarkable spinal fissure is from 4 to 3 lines. It does not exist in the vertebræ of the *Iguandon*, *Megalosaurus*, or other *Dinosauria*.

The base of the spinous process in this (presumed) *Poikilopleuron's* vertebra, instead of descending from behind forward in a graceful curve, as in the *Dinosaurs*, forms a straight and almost horizontal line, 3 inches in extent ; the spine maintains the same breadth to its summit, which is truncated rather obliquely ; its height is 4 inches 9 lines, measured from the upper end of the posterior zygapophyses ; it is thickened and rounded at its truncate summit. The height of the spine of a corresponding vertebra of the *Iguanodon*, with a centrum of the same length, is 9 inches. Thus the present vertebra more resembles, in the form and proportions of its spinous process, as in other characters, the vertebræ of the Crocodilians.

The posterior part of the neural arch, with the spinous process of the vertebra. here described, is figured in Mantell's 'Illustrations of the Geology of Sussex,' p. xii, fig. 1, as the "Lumbar Vertebra of the *Iguanodon*." It is not, however, a lumbar vertebra nor a part of the *Iguanodon ;* if it does not belong to the *Poikilopleuron*, it indicates an unknown genus of Crocodilians.

Nos. $\frac{294}{2294}$ and $\frac{295}{2295}$, in the Mantellian Collection, are the two moieties of a fossil caudal vertebra, fractured obliquely across the middle of the body, the length of which is to the breadth of its articular extremity as 3 to 2 ; both extremities are slightly concave ; the body is gradually contracted from the two extremities towards the middle part ; bears a transverse process developed from the posterior and upper part of its side, behind which there is a shallow groove ; has the neural arch anchylosed, without trace of suture, to nearly the whole of the longitudinal extent of its

upper surface. The neural arch is provided with anterior and posterior oblique processes, and a broad and thin spine developed at its posterior part, and strongly inclined backwards at its origin; lastly, the vertebra has a large medullary cavity in the centre of the body, filled, in the fossil, with spar. In all these particulars the Palæontologist acquainted with the excellent description by M. Eudes-Deslongchamps of the *Poikilopleuron Bucklandi*,* from the Oolite at Caen, will not fail to recognise the distinctive characters of that species in the present fossil. It is attached to a mass of the common Wealden stone which is quarried at Tilgate, and was associated with the bones of the *Iguanodon*.

The length of the present vertebra is 3 inches 9 lines, or $9\frac{1}{2}$ centimeters; that of the caudal vertebræ of the *Poikilopleuron* of Caen is about a decimeter.† We may conclude, therefore, that the individual from the Caen Oolite and that from the Wealden were of the same size, and, from this correspondence, it is most likely that the size—25 French feet, which M. Deslongchamps assigns to the entire animal—is the common size of the species.

From the size and position of the transverse process, the Tilgate vertebra corresponds with the second or third of the first series of caudal vertebræ of the Caen *Poikilopleuron* figured by M. Deslongchamps. There is one character in the Wealden vertebra which is not mentioned in M. Deslongchamps' description of the Caen species, viz. a longitudinal sulcus at the middle of the under surface of the body of the vertebra, at least, at its anterior half; the sulcus is not deep, and is 1 centimeter or 4 lines in breadth. The fortunate fracture which demonstrates the peculiarly large medullary cavity in the centre of the vertebral body gives the best proof that could be required of the generic identity of the Wealden vertebra with the Caen *Poikilopleuron;* and the absence of that cavity in the vertebræ of *Megalosaurus*, which I have determined by a section of one of the caudal vertebræ, establishes the distinction between that genus and *Poikilopleuron*.

In the form of its sub-biconcave vertebræ, and the simplicity of their neural arch as compared with the *Streptospondylus* and the *Dinosaurians,* the *Poikilopleuron* manifests its closer affinity to the amphicœlian Crocodiles. It agrees with the *Teleosaurus* in the comparative shortness of the fore legs; the mode of articulation of the vertebral ribs appears to be the same, and there is no evidence that it differs in the structure of the abdominal ribs.

The number of caudal vertebræ would appear to be greater; but I know not in what material respect the *Poikilopleuron* resembles the Lizard tribe more closely than does the *Teleosaurus*, unless it should be proved to have five toes on the hind foot, and to want the dermal armour. Subsequent discoveries may prove it to belong, like the *Megalosaurus*, to the *Dinosaurian* order; but as the *Poikilopleuron* is

* 'Mémoires de la Société Linn. de Normandie,' 4to, 1836.

† "Nos vertèbres ont chacune environ un décimètre de long."—Deslongchamps, loc. cit., p. 53.

at present known, it seems to have most claim to be received into the Amphicœlian family of the *Crocodilian* order, and perhaps has the closest affinity in that family to the *Crocodilus Bollensis*, Jaeger (*Macrospondylus*, H. v. Meyer).

Genus—Goniopholis, *Owen.*

This genus was determined, and so named, from the characteristic form of the teeth, which had been discovered in the Wealden strata of Sussex. These are remarkable, for the thick, rounded, and obtuse form of the crown, the enamel of which is marked by numerous close-set and neatly defined longitudinal ridges; two of these, larger and sharper than the rest, traverse opposite sides of the tooth from the base to the apex of the crown, midway between the convex and concave lines of the curvature of the tooth; the cement-covered, cylindrical base of the tooth is smooth. Such teeth vary from a length of crown of 2 inches, with a basal diameter of $1\frac{1}{2}$ inch, to teeth of one third these dimensions.

In the British Museum is preserved a slab of Purbeck limestone, with a portion of both endo- and exo-skeletons of a crocodile, in the lower jaw of which are preserved two teeth (Pl. 7), proving the specimen to have been identical with the *Goniopholis* of the Wealden strata.

Goniopholis crassidens, *Owen.* '*Crocodilia*,' Plates 7—13.

Our knowledge of this remarkably well-defined Amphicœlian Crocodile has been derived from a study of its fossil remains, obtained from deposits of the Wealden and Upper Oolitic periods.

The first indication of the genus was given by detached teeth from the Tilgate quarry, which presented a thicker and more robust form of crown than in other Saurian teeth of that period, the proportions being rather those of the teeth of the Procœlian Crocodiles and Alligators of the tertiary and modern times. From these, however, the Wealden ones differed in the longitudinal ridges of enamel traversing the exterior of the crown, which are numerous, close-set, and neatly defined. Two of the ridges, larger than the rest, traverse opposite sides of the tooth, and in the larger specimens from the base to the apex, being placed midway between the convex and concave outlines of the curve of the tooth (Pl. 11, fig. 3); in the smaller teeth, which intervene between the larger ones in the mandibular series, these opposite ridges are limited to

the apical half of the crown, to which they give somewhat of a trenchant character (Pl. 12, fig. 4). At the back part of the series the crown becomes obtuse (Pl. 7, fig. 2); as it also does in the *Crocodilus Hastingsiæ* ('Crocodilia,' Pl. 1 B, fig. 1), and in the *Croc. Spenceri* (Pl. 3, A, fig. 12).

On these characters the present genus and species were founded in my 'Report on British Fossil Reptiles.'*

In the British Museum is preserved the split slab of Purbeck limestone, quarried near Swanage, Dorsetshire, containing dislocated parts of a skeleton of a reptile, determined by the two teeth, fortunately retained in the part of the lower jaw preserved, to belong to the *Goniopholis*.

The first character which attracts the palæontologist's attention, in this remarkable specimen, is that which the numerous large, bony, dermal plates or scutes afford (Pl. 7. *d*). These are scattered irregularly over the slab, and in their number and relative size bring the species much nearer to the extinct Teleosaurs than to any of the existing Crocodiles; they differ, however, from both the dorsal and ventral scutes of the Teleosaur in their more regular quadrilateral figure; they are longer in proportion to their breadth than most of the Teleosaurian scutes, and are distinguished from those of all other Crocodilians, recent and fossil, that I have yet seen, by the presence of a conical, obtuse process (Pl. 1, figs. 1 and 2, *a*) continued from one of the angles vertically to the long axis of the scute; analogous to the peg or tooth of a tile, and fitting into a depression on the under surface of the opposite angle (ib., fig. 1, *b*) of the adjoining scute; thus serving to bind together the plates of the imbricated bony armour, and repeating a structure which is highly characteristic of the large bony and enamelled scales of many extinct ganoid fishes. Some of the scutes in the Swanage specimen are 6 inches in length and 2½ inches in breadth.

The exterior surface of the scute (Pl. 8, fig. 2) is impressed by numerous deep, round, oblong, or angular pits, from two to four lines in diameter, and with intervals of about two lines, formed by convex, reticularly disposed ridges of the bone; but a larger proportion of the anterior part of the scute is overlapped by the contiguous scute that in the Teleosaur, and this part is smooth, and thinner than the rest of the scute. The whole of the inner surface of the scute (ib., fig. 1) is smooth, but on close inspection it is seen to be everywhere impressed by fine, straight lines, decussating each other at nearly right angles, and indicating the structure of the corium in which the scutes were imbedded. Thus, from the size and strength of these dermal bones, their degree of imbrication, and the structure for interlocking, we may conclude that the *Goniopholis* was better mailed than even the extinct Teleosaur, which Cuvier regarded as "l'espèce la mieux cuirassée de tout le genre."†

In the slab in question the vertebræ (Pl. 7, *v*, *v*) were unfortunately all at right

* 'Reports of the British Association,' 1841, p. 69.

† 'Ossemens Fossiles,' tom. v, pt. 2, p. 1, 139.

angles to the exposed plane, and fractured across the middle, one extremity being buried in one of the halves of the slab, and the other in the opposite half. By permission of the Trustees of the British Museum, I was able, in 1841, to remove the matrix from the two extremities of the same vertebra, and so demonstrated that both articular ends were equally but slightly concave.

	Inches.	Lines.
The length of the body of the vertebra examined was	1	10
Vertical diameter of the articular extremity	1	9
Transverse diameter of the articular extremity	1	8
Ditto of middle of the body	0	11
Ditto of entire vertebra, including the transverse processes . .	10	0
Height of entire vertebra, including spinous process	4	4
From the lower part of the centrum to the base of the transverse process	2	6

The suture which joins the neural arch to the centrum is conspicuous; it forms an ascending angle or curve at its middle part. The body of the vertebra expands in a greater degree to form the subconcave articular surfaces than in other biconcave vertebræ of the same length; and both in this character and in its smooth surface and circular transverse contour at the lower part, the *Goniopholis* resembles the *Streptospondylus* more than it does the *Teleosaurus*.

The transverse processes of the lumbar and anterior caudal vertebræ are long, straight, and comparatively slender; those of the sacral vertebræ (Pl. 7, *s, s*) are relatively thicker, and the spaces enclosed by their expanded extremities are smaller than in either the Teleosaurs or Crocodiles. The antero-posterior extent of the two sacral vertebræ is three inches two lines.

The ilium (ib., *i*) is broader than in the existing Crocodilians; the bifurcation of the proximal end of the ischium (ib., *is*) is more marked, and the iliac branch is more regularly rounded; the pubic branch is longer, more slender, and its articular end is more regularly convex; the distal or lower part of the ischium expands into a relatively broader plate. This character is still more conspicuous in the pubis (ib., *p*), which equals the ichium in breadth, and begins to expand much nearer the proximal extremity than in the existing Crocodiles. In these modifications of the pelvis, as well as in the biconcave structure of the vertebra, the Crocodilian of the Purbeck limestone approaches nearer to the characters of the Enaliosaurs; and we may infer that its habits were more decidedly marine than are those of existing Crocodilians. The caudal vertebræ were provided with long, narrow, unanchylosed chevron bones.

The portion of the lower jaw preserved belongs to that part of the left ramus included between the articular extremity, which is broken off, and the commencement of the dental series; it measures 1 foot 6 inches in length, and 5 inches in greatest depth. In these proportions, and the curve of the lower margin, it deviates

from the ancient Teleosaurs and Steneosaurs, and resembles the modern Crocodiles; and although not quite equalling these in the robust proportions of the jaw, yet it much exceeds in this respect the Crocodilians with more slender teeth.

Portions of the skeleton of a *Goniopholis*, kindly submitted to my examination by G. B. Holmes, Esq., of Horsham, by whom it was discovered in a Wealden stratum at Cuckfield, Sussex, shows the symphysis of the lower jaw (Pl. 12, fig. 4) to have been as long in the *Crocodilus Spenceri* ('Crocodilia,' Pl. 2, fig. 2), a transitional form between the modern Crocodile and Gavial. The fore part of the premaxillaries (Pl. 11, figs. 1 and 2) shows a semicircular anterior contour, and a single subcircular nostril, placed rather nearer the termination of the muzzle than in existing Crocodiles, but yet above, not terminal, as *Teleosaurus*, not subterminal, as in *Steneosaurus*. There is not enough of the bone preserved to show whether there was a constriction of the upper jaw behind the nostril, as in the Gavial. The incisive foramen is not immediately beneath the nostril, as in the modern and tertiary Crocodiles (comp. Pl. 1, c, with Pl. 11, fig. 2). The outer surface of the premaxillaries is convex, rather irregular, with vascular foramina and wrinkled impressions. The margins of the symphysis are a little produced. There are four alveoli in each premaxillary, as far as the bone is preserved; they are proportionally larger, more numerous, and closer together than in the corresponding part of the *Streptospondylus* or *Steneosaurus brevirostrus* ('Ossem. Fossiles,' 4to, t. v., pt. ii, pl. x, fig. 6). The first and smallest socket is in contact with the second, which is the largest; the intervals increased beyond this socket (Pl. 11, fig. 2). The palatal surface shows a pair of large and deep approximate fossæ, and a second pair of smaller fossæ for lodging the crowns of the anterior teeth of the lower jaw. This is very slightly expanded at its anterior end, where the larger (third and fourth) tusks are implanted. The fragments of the mandible indicate a symphysis of, at least, eight inches in length; at the anterior three inches the rami interlock by strong, radiating ridges and grooves (Pl. 12, fig. 1).

The teeth are well preserved in parts of these fossil jaws the cylindrical fang is invested by smooth cement; the coronal ridges begin at the basal line of the enamel, and proceed nearly parallel to the apex of the cone. In a tooth with a crown one inch long and half an inch across the base four ridges are included in a space one line broad; a few of the ridges are interrupted to preserve the parallelism of the rest. Towards the apex a number of shorter and finer ridges are present on each side of the two chief ridges, to which they obliquely converge. At the extreme apex of an unworn tooth the ordinary ridges terminate in fine, slightly wavy lines, forming a subreticulate surface.

In the Jurassic *Crocodilian*, called *Madrimosaurus* by V. Meyer, the coronal ridges of the teeth are more numerous, are smaller at the base of the enamel, and more of the ridges are interrupted than in *Goniopholis;* the entire tooth also seems to be shorter and thicker.

Examples of the successional teeth are shown at *a*, fig. 3, Pl. 11, and at *a*, fig. 2, Pl. 12.

Since the characters of the teeth in the Purbeck *Goniopholis* are only known by the two posterior ones of the lower jaw, the Wealden species may be distinct. The large intervals and unequal size of the teeth behind the anterior four or five mandibular teeth are shown in Pl. 11, fig. 4, and 11, 12, figs. 3, 3, *a*, and 4, from the Wealden specimen.

Cervical Vertebræ ('*Crocodilia*,' Pl. 10, figs. 1—5.)

The three vertebræ represented in the above-cited plate were obtained by Mr. Holmes from the same bed of Wealden clay, at Cuckfield, as the teeth and scutes characteristic of the genus *Goniopholis*, to which, therefore, I refer them. They correspond with the fourth, fifth, and sixth cervical vertebræ of the recent Crocodile, having a parapophysis similar in form, extent, and position, with traces of a short and thick hypapophysis (comp. fig. 1, Pl. 10, with fig. 2, *h*, Pl. 3, A) at the fore part of the under surface; but behind this the under surface of the Wealden vertebra is less convex, the whole centrum is relatively broader, and the more important difference of the concavity of the hinder as well as of the front articular end manifests the distinct family of *Crocodilia* to which the *Goniopholis* belongs. The depth of the concavity of these surfaces exceeds that in *Teleosaurus*. The free surface of the centrum is smooth. The neural arch articulates with the whole length of the centrum, which is impressed by a neural channel, slightly widening behind, between the neurapophysial surfaces (Pl. 10, fig. 5). Two vertical, venous canals open into the neural canal. Fig. 6 is the side view of a cervical centrum from the Purbeck beds, having the general proportions of those of *Goniopholis*, but differing in the smaller size of the parapophysis. Figs. 7—9 are views of the centrum of a dorsal vertebra of a Wealden *Goniopholis*, fig. 9, showing the texture as displayed by a vertical longitudinal section. This shows a close, cancellous structure throughout, whereas the centrums in the *Teleosaurus* (Pl. 9, fig. 6) exhibit a more open, reticulate texture, with a cavity near the centre.

One of the posterior caudal vertebræ, after the subsidence of the diapophyses and the great reduction of the zygapophyses, shows the spinous process rising from the hinder half the neural arch, as at *g*, Pl. 13.

The coracoid (Pl. 13, *k*) differs from that of the existing Crocodiles in its greater relative breadth at the neck or part marked *k*, in the more gradual and minor expansion of its mesial end, and in the more regular convexity of its scapular border. It exhibits the same perforation near this border as in the modern Crocodiles.

The humerus associated with the remains of *Goniopholis* from the Wealden of Cuckfield has the usual Crocodilian form and sigmoid flexure. Compared with one

from a *Crocodilus biporcatus*, with the same-sized cervical vertebræ, it is a somewhat thicker and stronger bone (see p. 102). It has a broader and thicker ulnar tuberosity, and the angle at which the process is bent down upon the shaft is less marked, more rounded off. The radial crest is a triangular, compressed ridge, but is not produced beyond four lines from the surface of the shaft; the distal part of the bone is proportionally thicker antero-posteriorly than in the modern Crocodiles, and the longitudinal, irregular ridges at the margin of the articular surface are stronger; there is a similar ridge above the inner condyle.

The femur of the *Goniopholis* (Pl. 13, *o*) is relatively longer, and is less bent than in the existing Gavial or Crocodile. The tibia (*m* and *n*, the latter bone presenting its narrower side to view) is also both longer and thicker.

Dermal Scutes (Plates 9 and 13).

In the slab of Wealden stone from Cuckfield, containing the parts of the dislocated skeleton shown in Pl. 13, there were imbedded, not only the long, quadrate, toothed scutes (*a*, *b*), like those in the Purbeck slab (Pls. 7 and 8), but a second form of scute (Pl. 13, *d*, *d*), of which no examples had been preserved in the Purbeck specimen. These scutes are hexagonal, marked as in the toothed kind, on the outer surface, by hemispheric, circular or subcircular pits, and on the inside by fine, linear, decussating lines on an otherwise smooth and plane surface (Pl. 9, fig. 2). They have no articulating process, but have a strongly marked sutural surface on the thick margin (ib., fig. 5), showing them to have been united together, like the neural and costal plates of the carapace, and like the elements of the plastron, in the terrapene and tortoise.

From the association of hexagonal sutural scutes with the quadrate, oblong, toothed scutes in the specimen (Pl. 13), it can hardly be doubted that they formed part of the same exo-skeleton. But to what part of such skeleton each kind was appropriated cannot be determined until more complete examples are discovered.

In the sixth part of the sixth volume of the 'Palæontographica' of H. v. Meyer, the author has described and figured part of the dermal skeleton of what he believes to have been a Saurian reptile, consisting of bony plates, for the most part hexagonal and united by marginal sutures. These plates, however, do not present the uniformly pitted character of the external surface, as in *Goniopholis;* but here and there in the series they show a few irregular, large depressions; the more constant markings are smaller, apparently vascular foramina, and linear, usually radiated, impressions in character more like the markings of the dermal ossifications of the Labyrinthodont reptiles. The specimen described is from the "dachsteinkalk," under the Winkelmaass Alpe, near Ruhpalding, in Bavaria, and it is referred to the *Psephoderma Alpinum.*

Genus—SUCHOSAUROS,* *Owen.*

SUCHOSAURUS CULTRIDENS, *Owen.* '*Crocodilia,*' Pl. 5.

In the Wealden formations have been found detached teeth and vertebræ, indicating the existence, at that period, of a large Amphicœlian Crocodile specifically and generically distinct from the *Goniopholis;* for, since the discovery of associated bones and teeth of the latter genus have made us acquainted with its vertebral characters, the other remains, upon an exhaustive analysis of the reptilian fossils of the Wealden series, leave only the form of Saurian tooth (Pl. 5, fig. 4) wherewith to associate the equally peculiar form of Saurian vertebra (Pl. 5, figs. 1—3). This vertebra is readily distinguishable, by the length of the centrum and the compressed, wedge-shaped character of its middle part, from all other known Saurian (Dinosaurian or Crocodilian) vertebræ of the Wealden period. The specimen is No. $\frac{138}{2138}$, Mantellian Collection of Wealden fossils in the British Museum (Pl. 6, figs. 1, 2, 3), and is the body of a dorsal vertebra, with both articular extremities slightly and equally concave; though narrower at the middle than at the ends, it is more uniformly compressed than in other Crocodilian vertebræ, the sides converging to an inferior obtuse ridge, which is very slightly concave in the antero-posterior direction. The sides are not flat in the vertical direction nor slightly concave, as in many of the Iguanodon's vertebræ, to which the present form approximates; but are gently convex, so that a pencil laid vertically upon the side touches it only by its middle. A more decided difference between the present Crocodilian vertebræ and those of the Iguanodon is, that the former are longer in proportion to their height and depth. The external surface at the middle of the body of the vertebra is very finely striated, so as to present a silky appearance; near the margins it is sculptured by coarse, longitudinal grooves and ridges.

The base of the neurapophysis (ib., fig. 3, *b*) which, when anchylosed, leaves an evident trace of the suture, is nearly equal in length with the body of the vertebra (ib., *a*); it does not wholly include the spinal canal, but leaves the impression of the lower third of that canal upon the upper surface of the centrum. On the outside of the neurapophysis are two slightly developed, broad, obtuse, ridges converging towards each other from the outer side of each angle or end of the base of the neurapophysis; the ridge corresponding with the posterior of these in the Iguanodon's vertebra rises more vertically, and is in higher relief. The neurapophysial suture slightly undulates in its horizontal course, and rises in the middle instead of descending upon the centrum, as in the Plesiosaurs.

* Greek Σοῦχος, an Egyptian name of the Crocodile, and σαῦρος, lizard.

The present vertebra is alluded to at p. 60, and figured at pl. ix, fig. 11, of Dr. Mantell's 'Illustrations of the Geology of Sussex,' as a lumbar vertebra of the *Megalosaurus*. But in the 'Geology of the South-east of England,' the same author, speaking of this vertebra, observes, "It cannot, I now think, be separated from those figured in the same plate as belonging to a Crocodile."—p. 297. Fig. 8, Pl. 9 (Tilgate Fossils) is, however, a caudal vertebra of the *Cetiosaurus*. The body of the Megalosaurian vertebra has a pretty deep, longitudinal depresssion below the neurapophysial suture, wanting in the Tilgate vertebra here described. This, however, is not the only distinction; below the depression the centrum of the Megalosaur swells out, and is as convex below as it is laterally in the transverse section, so that the outline of a transverse section would describe five sixths of a circle; a similar section of the vertebra of *Suchosaurus* would be triangular, with the apex rounded off. The Megalosaurian vertebra is more contracted at the middle, and swells out near the articular ends, surrounding those articulations with a thick convex border; in *Suchosaurus* the lateral meet the marginal surfaces at a somewhat acute angle; but the silky, striated surface of the Suchosaurian vertebra, and the smooth and polished surface of the Megalosaurian one, would effectually serve to distinguish even fragments from the middle of the body of each.

The following are dimensions of the vertebra of the large Wealden Crocodilian above described:—

	No. 138.	
	Inches.	Lines.
Antero-posterior diameter of the body	3	10
Vertical diameter of its articular end	3	2
Transverse diameter of its articular end	2	9
Transverse diameter of the middle of the body	2	0

The fossil teeth from the Wealden (Pl. 5, fig. 4), which I provisionally associate with the foregoing vertebræ, approach by their more slender and acuminated form to the character of those of the Gavial, but differ from the teeth of any of the recent species of that sub-genus of Crocodilians, as well as from those of the long and slender-snouted extinct genera, called *Teleosaurus*, *Steneosaurus*, &c. The crown is laterally compressed, subincurved, with two opposite trenchant edges, one forming the concave, the other the convex, outline of the tooth. In the Gavial the flattening of the crown and the situation of the trenchant edges are the reverse, the compression being from before backwards, and the edges being lateral.* The tooth of the Suchosaur thus resembles in form that of the Megalosaur (Pl. 5 fig. 5), and perhaps still more those of the Argenton Crocodile; but I have not observed any specimens of the Wealden teeth in which the edges of the crown were serrated, as in both the reptiles

* The tooth attributed by M. Deslongchamps to the *Poikilopleuron* agrees in form with those of the Gavial, and differs in the characters cited in the text from those of the *Suchosaurus*.

just cited. The teeth of the Suchosaur also present a character which does not exist in the teeth of the Megalosaur, and is not attributed by Cuvier,* to those of the *Crocodile d'Argenton.* The sides of the crown are traversed by a few longitudinal, parallel ridges, with regular intervals of about one line, in a crown of a tooth one inch and a half in length ; these ridges subside before they reach the apex of the tooth, and more rapidly at the convex than at the concave side of the crown.

Hitherto these teeth have not been found so associated with any part of the skeleton of the same species as to yield unequivocally further characters of the present extinct Crocodilian. From the above-mentioned well-marked differences between these teeth and those of all other known species, I regarded the extinct Crocodile as forming the type of a distinct genus and species, and proposed for it the term *Suchosaurus cultridens.*†

* Cuvier, 'Ossem. Fossiles,' 8vo, tom. ix, p. 331.

† 'Report on Brit. Fossil Reptiles,' 1841, p. 67.

ORDER—*PTEROSAURIA.*

SUPPLEMENT No. II.

PTERODACTYLES OF THE CRETACEOUS FORMATIONS.

Genus—PTERODACTYLUS, *Cuvier.*

IN the first supplement to the present order, on the Pterodactyles of the Upper Green-sand of Cambridgeshire, I described,* figured,† or referred to, parts of a Pterodactyle from an individual surpassing in size that to which the portions of upper and lower jaw‡ belonged on which the species dedicated to Professor Sedgwick was founded. Such fossil evidences of more gigantic flying reptiles, showing no better distinctive characters than size, were deemed, probably, to belong to the *Pterodactylus Sedgwickii*, the then largest known species of the genus.

I am now, however, enabled to adduce, from the more recently acquired additions to the Woodwardian Museum at Cambridge, supplied to me by the same unfailing liberality of the eloquent Professor, evidences of a much larger Pterodactyle, distinct, in regard to the form of the skull, from any previously known, and one which, assuming that the portion of upper jaw of *Pterodactylus Sedgwickii* (Pl. 7, fig. 1) belonged to a full-grown specimen, must have acquired at least double the dimensions of that species.

* Page 382.

† Plate 7, fig. 6.

‡ Ibid., p. 379, plate 7, figs. 1 and 2.

PTERODACTYLUS SIMUS, *Owen.*

Jaws and teeth (Pl. 11, figs. 1—10).

The first evidence I have to offer of this truly gigantic flying reptile consists of the corresponding part of the upper jaw with that on which the *Pterodactylus Sedgwickii* was founded, viz. the anterior extremity forming the muzzle (Pl. 11, figs. 1—5), including the first four (*a, b, c, d*) and part of the fifth (*e*) sockets of the teeth. The comparison and appreciation of the specific distinctions of the two large Pterodactyles are thus rendered easy and satisfactory.

In the specimen of *Pterodactylus simus* (Pl. 11, figs. 1—5), the first tooth (*a*) on the left side remains in the socket; it is not larger than the corresponding tooth in *Pterodactylus Sedgwickii*, and, consequently, is relatively much smaller than in that species. Its socket and that of its fellow, moreover, are differently situated, opening downwards, like the succeeding sockets, and the position of the exserted foremost tooth is accordingly vertical and nearly parallel with the lower half of the anterior contour of the muzzle. In *Pterodactylus Sedgwickii,* the sockets of the first pair of teeth open upon the fore part of the muzzle, and look almost directly forward,* and their teeth had, consequently, a nearly similar direction; the same, viz. which they appear to have had in *Pterodactylus suevicus*, Qnst.†

The contour of the muzzle in *Pterodactylus Sedgwickii* rises at first vertically above these sockets before curving back into the upper part of the skull's profile, and gives an obtuse anterior termination to the upper jaw;‡ but this character is much exaggerated in the present specimen (Pl. 11, figs. 1 and 3), not only by the greater relative extent of the vertical part above the front sockets, but by the greater breadth of that part, which is flattened anteriorly, forming a surface (fig. 3) of nearly 2 inches in length, about 10 lines in breadth below, and contracting gradually above to a point, where the blunt ridge begins that forms the upper part of the profile of this portion of the skull. The name proposed for the species refers to this peculiarly obtuse and flattened fore part of the cranium. In *Pterodactylus Sedgwickii*, the upper ridge of the fore part of the cranium is continued down to between the first pair of sockets,§ the muzzle being only obtuse vertically, and not transversely, as in *Pterodactylus simus.*

The flattened anterior surface, in the specimen figured (Pl. 11, fig. 3), is im-

* Plate 7, fig. 1, *c*.

† 'Ueber *Pterodactylus suevicus*,' &c., 4to, 1855, tab. i.

‡ Page 380, pl. 7, fig. 1.

§ Plate 7, fig. 2.

pressed by a very shallow and wide, longitudinal or vertical channel; but this is scarcely marked in a second specimen of a muzzle of the same species. In both specimens the outer surface of the flattened part is less smooth than at the sides of the muzzle, being impressed by numerous irregular, linear grooves, seemingly vascular, affecting the vertical direction at the upper part, and the transverse direction at the rest of the surface.

The ridge where the two sides of the muzzle meet, above and beyond the flattened surface, is more obtuse and is relatively thicker than in *Pterodactylus Sedgwickii.* Were the same curve to be continued from the part of the ridge preserved until it became horizontal, the vertical diameter of the skull at this part would be not less than three inches; it may, however, have arisen to a greater height, for the contour is not regularly curved, but subangular, as shown in figs. 1 and 2, Pl. 11.

The facial part of the skull must have been narrow in proportion to its height, and, no doubt, also to its length. The broadest part of the present fragment does not exceed one inch and a quarter at the fourth pair of sockets; the adherent matrix (*m, m,* figs. 4 and 5) gives a seeming greater breadth to this part of the skull.

The sockets of the first pair of teeth (*a*) are three lines apart, the interspace equalling the largest diameter of the socket; the bone forming this anterior termination of the palate projects as a convexity below the level of the alveolar openings, the plane of which is a little inclined outwards. This inclination is increased in those of the second pair of sockets, which are nearly double the size of the first, and are five lines apart. The second is separated from the first socket by an interval of two lines; its outlet has a full, oval form. The third socket is four lines distant from the second, and exhibits the same ratio of increase of size; there is a shallow, vertical depression on the outer alveolar wall, between the second and third tooth, the socket of the latter appearing to have made a slight prominence on that part of the jaw. The palate at the interspace between the second and third pairs of sockets is flat, showing no trace of the median ridge characterising that part of the upper jaw, or of the groove at the corresponding part of the lower jaw, in the *Pterodactylus Sedgwickii.*

The upper jaw of the *Pterodactylus simus,* in the present specimen, has been partially fractured across the third pair of sockets (figs. 1 2, 5, *c*), of which only the fore part of the left one is here preserved, showing well-marked vascular grooves. Its outlet, from this fracture, appear to be of a larger oval or ellipse than in the second socket.

The fourth socket (*d*) is preserved only on the right side, with about the right half of the corresponding part of the bony palate. The outlet of this socket resembles in shape and size that of the second; it is three lines distant from the third socket.

The fifth socket (*e*), the fore part of which is preserved on the right side, is four lines distant from the fourth.

The thinness of the compact outer wall of this fragment of the upper jaw, and the large size of the cancelli, concur with the dental characters in demonstrating the Pterosaurian nature of the fossil. So far as the outer wall is preserved it shows no trace of the external nostril at a distance, viz. of three inches from the fore part of the upper jaw.

The tooth in place is sub-compressed, conical, long, and slightly curved, with the convexity forward. The portion of enamel preserved on the crown accords with the Pterosaurian type of tooth in its thinness, in the very delicate, irregularly wavy, sometimes branching, longitudinal ridges, on its outer surface; the dentine is compact, and is coated by cement at the base of the tooth.

PTERODACTYLUS WOODWARDI. Pl. 12, figs. 3, *a*, *b*, *c*.

The specimen from Professor Sedgwick's collection, represented of the natural size in Pl. 12, fig. 3, *a*, *b*, is a transverse fragment of the jaw of a Pterodactyle, from the Upper Green-sand of Cambridgeshire, showing a greater divergence of the side walls towards the alveolar or oral surface, and, consequently, greater breadth of that surface in proportion to the height or vertical extent of the part than in the *Pter. simus.* Of the oral surface too small a portion is preserved to indicate whether it be palatal or mandibular. By the characters of the median ridge or groove pointed out at pp. 381, 381, I incline to regard it as part of the upper jaw, corresponding in the proportions of height and palatal breadth with that of the *Pterodactylus Fittoni* (Pl. 7, fig. 3), but coming from a part of the jaw further from the anterior extremity.

The fractured ends show the characteristic thinness of the compact, bony wall and the large (air- ?) cells occupying its substance.

The side wall, which is most entire, has been abraded (Pl. 12, fig. 3, *b*), but the small portions of the preserved surface exhibit the smooth character of Pterosaurian bone. The fragment includes a pair of sockets, with the bases of their teeth. The latter show the usual elliptical, transverse section (fig. 3, *c*). The implanted base of the tooth extends three fourths of the way to the upper border of the jaw; it has a coat of cement half a line thick, with the outer surface longitudinally ridged, corresponding with the grooves of the socket. The direction of the socket shows that the tooth extended obliquely forwards and outwards as well as downwards.

Pl. 14, fig. 4, shows the part of the base and basal half of the crown of a tooth of a Pterodactyle, from the Upper Green-sand of Cambridgeshire, a little surpassing in size that of which the base is shown implanted in the socket of the

portion of jaw (Pl. 12, fig. 3), and of that figured in Pl. 7, fig. 6, *a, b, c*. The total length of the tooth (fig. 4) cannot have been less than 4 inches.

If the present fragment has belonged to an individual of the same species as that on the upper jaw of which the *Pterodactylus Fittoni* is founded, it shows such species to have attained more than double the dimensions indicated by the original specimens figured in Pl. 7, figs. 3 and 4. Should the present fragment prove to belong to a distinct species, with the sides of the jaw meeting above, at a less acute angle, and with the wall of the outlet of the socket less prominent externally, such species may be indicated as the *Pterodactylus Woodwardi,* in honour of the founder of the Geological Collection of the University of Cambridge.

The Mandible (Pl. 11, figs. 6—10).

The portion of the right ramus of the lower jaw, or mandible, figured in the above-cited plate, may have belonged, by its size, to either of the gigantic Pterodactyles above specified as *Pt. simus* and *Pt. Woodwardi.* Its texture and configuration show it to have formed part of a Pterosaurian skeleton. It is the part of the ramus which answers to the angular, sur-angular, and articular elements in the *Pterodactylus suevicus,** but with only a part of the sutures between the angular and sur-angular remaining on the inner side of the bone. The angle is partially fractured, but seems to have been not much produced beyond the articular concavity.

The ramus, as it extends forward from the articular part, at first diminished slightly in breadth and depth, then increases in vertical, whilst continuing to decrease in transverse, extent.

The outer surface (fig. 7) presents, near the articular cavity, a shallow, longitudinal depression, bounded below by a rather sharp border; a broader and more shallow depression, the lower boundary of which is well defined, marks the more advanced part of the ramus. These depressions indicate the insertions of muscles.

Both the upper (fig. 9) and lower (fig. 8) borders are obtusely rounded, the latter being the thickest. Along the inner side of the fragment a longitudinal channel (fig. 6, *e*) extends near the lower border, the upper boundary of the channel being produced inwards, especially posteriorly (*b*); above this boundary there is a deep, longitudinal depression (*d*) partly filled with matrix, and probably communicating with the (pneumatic ?) cavity of this part of the jaw-bone.

The longitudinal depression (fig. 6, *d*) is bounded below by the angular element,

* Quenstedt, 'Ueber *Pterodactylus suevicus,*' 4to, 1855, tab. i, figs. 2, 4, 5.

or part answering to that marked 2 in *Pterodactylus suevicus,* and above by the surangular (*c*). This element appears to have coalesced with the articular one; but between the bone (*a, c*) and that marked *b* a true harmonia or toothless suture remains. The line below the letter *e*, in fig. 6, appears to be an accidental crack. The fractured anterior end of the fragment (fig. 10) indicates the extreme thinness of the wall of the bone, which consists of compact osseous substance. A part of the concave, articular, surface is shown at *a*, fig. 7.

A similar longitudinal depression on the inner side of the back part of the ramus, with its lower boundary produced as a ridge, and formed by the angular element (2), is indicated in the figure of the lower jaw of the *Pterodactylus suevicus* in Professor Quenstedt's memoir; according to the proportions of which jaw, the present comparatively enormous fragment would answer to almost the hinder half of that part of the ramus which has not united with its fellow to form the long symphysis, and it may be estimated as including one fourth of the entire length of the lower jaw, which would give to the Pterodactyle, yielding the present mandibular fragment, a head exceeding sixteen inches in length. It is probable, however, that the head of *Pterodactylus simus* was relatively shorter and thicker than in the smaller species of Pterodactyle.

The Basi-occipital (Pl. 11, figs. 11, 12, 13).

A skull of the size above indicated would require an occipital condyle at least as large as that on the basi-occipital element figured in the above-cited plate. This condyle projects backward on a well-marked base too broad to be called a peduncle; the convexity is only hemispheric, with the transverse diameter predominating; its shape and position indicate great freedom of movement of the head upon the spine. There is no mark of a sutural surface for the exoccipitals on the expanded part of the bone (*b*); they were probably confluent, as in birds, with the basi-occipital, and have been broken away; the fractured surface (fig. 12, *b*) shows the large cancelli of this part of the occipital bone. The upper surface (*a*) indicates a wider foramen magnum, or neural canal, than that of the combined atlas and axis (fig. 14, *n*), and such a structure accords with the free and extensive movements of the head upon the spine indicated by the form and prominence of the condyle and its occipital cup (*c*).

Atlas and Axis (Pl. 11, figs. 14, 15, and 16).

The anchylosed atlas and axis (figs. 14, 15, and 16) correspond in size with the above-described basi-occipital; they were obtained at the same time from the

same pit of the Upper Green-sand deposit near Cambridge. The condyloid ball (fig. 12, *c*) neatly fits the cup *c* of fig. 14, and most probably belonged to the same individual. All the characters described and figured in my paper on the 'Vertebræ of Pterosauria,'* and in a preceding monograph,† are repeated in the present larger specimens of the first and second neck-vertebræ. In the more transverse extension of the posterior articular ball of the axis (fig. 16, *b*) the present specimen agrees with the smaller of the two previously figured specimens of this part of the vertebral column.‡

Cervical Vertebræ (Pl. 12, figs. 1, 2, and 4).

The middle (fourth or fifth?) cervical vertebra of a Pterodactyle, corresponding in bulk with that indicated by the fossils above described and figured (Pl. 11, figs. 1—16; Pl. 12, figs. 1—3), agrees in the proportions of length and breadth more with the smaller vertebræ (Pl. 8, figs. 14—17) than with the vertebræ (ib., figs. 7—11) described in pages 386—388. It shows the same posterior extension of the centrum (fig. 2, *b*, *p*) beyond the neural arch (*n*), but with somewhat greater divarication of the hinder processes (*p*) than in figs. 18 or 11 of Pl. 8. The present specimen very strikingly illustrates the characteristic breadth and depression of the centrum of the middle cervicals of the large Green-sand Pterodactyles. The neural canal (fig. 2, *n*) appears to be proportionally more contracted than in the smaller cervical vertebræ; it is relatively much smaller than in any bird, marking well the reptilian nature of the extinct flying air-breather. The anterior surface of the diapophysial productions of the fore part of the base of the neural arch is marked by a groove extending from above and within outwards and downwards. The whole base of the arch has coalesced with the centrum; the major part, with the neural spine and zygapophyses, has been broken away.

An oblique side view of the last cervical vertebra of a similar-sized Pterodactyle is given in Pl. 12, fig. 4, showing the more produced diapophysis (*d*), perforated by vertebrarterial foramen (*f*), indicative of the development in this vertebral segment of a rudimental rib, and of its coalescence with the other elements, the whole extending below the level of the under part of the centrum. Above and behind this foramen is that for the admission of air into the bone; it is of a similar size, and of a narrow, elliptical form. The posterior zygapophysis (*z*) is now raised to a higher level than the anterior one, indicating the sudden bend of the neck at this part. The posterior processes (*p*) are smaller and less

* 'Philosophical Transactions,' 1859, p. 165, pl. 10, figs. 28—34.

† 'Palæontographical Society,' vol. for 1857, pp. 7, 8.

‡ Compare Tab. I, fig. 16, with Tab. II, fig. 14, and Tab. IV, fig. 2, of the 'Monograph' of 1857.

produced; the body of the vertebra is narrower, but deeper, than in the more advanced vertebra (fig. 1). The posterior zygapophysis is surmounted by a tubercle.

Caudal Vertebræ (Pl. 12, figs. 13—16).

The caudal vertebra, from the anterior half of the tail (figs. 13 and 14), presents a size corresponding with the proportions of the Pterodactyle given by the above-described neck-vertebræ; the neural arch and zygapophyses continue to be distinctly developed at this region of the tail. There is a foramen (*o*), leading into the substance of the neural arch, on each side of the back part of that arch, and near the corresponding outlet of the neural canal. In the more distal vertebræ (figs. 15 and 16) the neural arch has sunk, and seems almost blended indistinguishably with the centrum, which is not longer than in the vertebræ nearer the trunk. The zygapophyses cease to be developed; but the articular, shallow cup and ball at the ends of the vertebræ show that the tail retained its mobility, and was not stiffened or anchylosed as at the corresponding part in *Ramphorhynchus*.

The Sternum (Pl. 12, figs. 7—12).

According to the very able and instructive summary, by Herman v. Meyer, of the osteology of the best-preserved examples of the skeletons of Pterodactyles, those, viz. from the lithographic slates of the Jurassic (Mid-oolitic) series of rocks, the sternum is a compound bone, consisting chiefly of a symmetrical, keelless, broad plate,* having an anterior process answering to the episternal process in the crocodile,† and with distinct side parts, having articulations for a few bony, sternal ribs.‡ As to its resemblance, otherwise, to the sternum of mammals, birds, or reptiles, in regard to the articular surfaces for the scapular arch, nothing has been, hitherto, determined.

* "Das Brustbein ist ein schwach gewölbtes knöchernes Schild, das breiter als lang, und daher eher dem Brüstbein der nur kümmerlich mit *Flügeln* versehenen Strauss-artigen Thiere beider Erdhälften, als dem in den Flug-begabten Vogeln zu vergleichen ist. Es zeigt keinen Kiel öder Gräth, und Man könnte daher glauben, das die Stelle zum Ansatz eines kräftigen Flugmuskels fehlt, die Pterodactyln keine gute Flieger gewesen wären." ('Reptilien aus dem Lithographischen Schiefer,' fol., 1859, p. 17).

† "Am Brustbein der Pterodactyln wird ein vorderer Forsatz wahrgenommen, der den Kiel ersetzt und den Brustmuskeln als Anheftungsstelle gedient haben wird. Dieser Theil erinnert au den Forsatz am Brustbein des Crocodils." (Ibid., p. 18.)

‡ "Bei *Ramphorhynchus Gemmingi* fand ich ausser den gewohnlichen Brustbein nach eine Platte mit Brustrippe welche die Verbindung mit den Kückenrippen unterhalten haben werden und wie in den Vogeln knöchern waren." (Ibid., p. 18, tab. x, fig. 1.)

The rich repository of remains of gigantic Pterosauria in the Upper Greensands of Cambridgeshire have added valuable evidence on these important points, and demonstrate a nearer approach to the keeled character of the breast-bone of flying birds than the specimens of the smaller species described in the undercited works appear to demonstrate. By the kindness of Professor Sedgwick, I am enabled to compare the specimens of portions of the sternum acquired by the Woodwardian Museum with that which has recently been purchased by the British Museum. The best of these specimens consist of little more than the thicker and stronger, contracted fore part of the breast-bone (Pl. 12, figs. 7, 8, and 9), broken away from the thin, expanded, fragile plate (*h*), of which it principally consists, and of which remains or impressions have been preserved in a few slabs of fine-grained stone of the Oolitic series, such as the lithographic slate; that of *Pterodactyles suevicus** showing the posterior border of the symmetrical plate to be convex and entire, not notched or perforated, as in many birds. The fore part of the sternum of the gigantic Pterodactyle from the Cambridge Green-sand includes the major part of the anterior process, and also the pair of articular facets for the coracoids. The keel-like process in the specimen (Pl. 12, figs. 7, 8, 9, *b*, *e*, *f*) is continued forward from that articular region (*d*, *c*), for an extent equal to the depth of the bone at the same part; but the process is not entire. Its base is gently convex at the sides, from the middle and thickest part of which it gradually narrows to a ridge, at about a line or less in thickness at both the upper and under margins; the extreme fore part being broken away, prevents the determination of the precise extent or contour of that end, but the convergence of the preserved parts of the upper and under margins indicate a convexly rounded termination (fig. 7, *e*). There is a gentle depression on each side of the beginning of the upper part of the ridge, which ridge is continued from a thickening or tubercle (figs. 7, 8, *b*), bounding anteriorly a small, deep, transversely oval depression (*d*) between the two articular surfaces for the coracoids (*c*). This tubercle answers to what I have termed the "manubrial process" in the sternum of birds,† and the above pre-coracoid part of the sternum answers to that process, confluent below, as in *Aptenodytes*, with the produced "keel." This, however, in *Pterodactyles*, quickly loses depth as it extends backwards along the mid-line of the under part of the sternum, some way behind the articular region, and has not quite subsided at the fore part of the expanded body of the breast-bone (fig. 9, *f*), from which the rest of the shield-like plate has been broken away. The sides of the post-coracoid part of the keel are gently concave; the lower border of the keel is first convex, then concave to near its posterior termination, both in a very feeble degree (fig. 7, *e*, *f*). Each of the articular surfaces for the coracoid

* Quenstedt, 'Ueber *Pterodactylus suevicus*, im Lithographischen Schiefer Würtembergs,' 4to, 1855.

† Art. "Aves," 'Cyclopædia of Anatomy and Physiology,' vol. i, 1836, p. 282, fig. 129.

(figs. 7 and 8, *c, d*) is sub-triangular, convex transversely, concave in the opposite direction, with the lower angle continued down upon the side of the thickest part of this anterior portion of the sternum. The back part of the articular surface rises higher than the front, so that the general aspect of the surface is obliquely upward, forward, and outward. The two surfaces are separated by a non-articular depression (*d*), of the breadth of one coracoid surface; this depression is bounded, like the sella turcica of the human sphenoid, by a transverse rising or ridge of bone (fig. 7, *a*), continued between the hinder angles of the two articular surfaces, and in front by the manubrial tubercle (*b*), from which the upper border of the produced keel is continued. The sternum contracts behind the articular region at *g*, figs. 8 and 9, and then expands rapidly in the horizontal direction, to form the broad, lamelliform body of the bone (*h*), which, in *Pterodactylus suevicus*,* appears to have been almost semicircular in shape, and to have extended backward beneath about one half of the thoracic abdominal cavity. The upper surface of the fore part of the sternal plate is concave, and it becomes flatter as it expands. The lateral and lower surfaces are also concave vertically, with linear markings, showing the implantation of the pectoral muscles that filled those concavities on each side the keel. Sufficient thickness of the bone remains at the fractured posterior part (*f*), where the keel has not subsided, to show the widely cancellous, and seemingly pneumatic, texture of the bone.

The similar, but smaller and more mutilated, portion of a sternum of a Pterodactyle (Pl. 12, figs. 10—12) shows the same form and position of the coracoid articular surfaces, the non-articular intermediate depression, the lateral emarginations or contraction of the sternum behind the part supporting the coracoids, and the backward extension of the keel beneath a certain proportion of the expanded body of the sternum, forming the hollows for the lodgment of the pectoral muscles.

A sternum of the shape and proportions above described plainly indicates pectoral muscles of great bulk and strength, by the extent of origin it afforded to them, and by the depth of the depressions they filled on each side of the keel; but to what purpose the limbs moved by those muscles were put is best inferred from the characters of the bone into which they were inserted. If, however, the peculiar development of the fore limbs of the Pterodactyle had not been known, the evidence of a pneumatic or widely cancellous structure in the thicker fore part of the breast-bone would have suggested a power of locomotion in its original possessor akin to that of the class to the sternum of which that of the Pterodactyle makes, upon the whole, the nearest approach.

It is true that the sternum is broad and shield-shaped in the Apteryx and other land-birds devoid of the power of flight; but this form, together with the

* Quenstedt, op. cit.

strong coracoids and their articulation with the sternum, relates, in them, to the mechanism of respiration. The ossified sternal ribs, with their articulations to the sides of a broad sternum, indicate a like function of the breast-bone in the Pterodactyle, viz. to expand the thoracic abdominal cavity, when such plate of bone, with attached but jointed sternal ribs, was pressed down by the coracoids.* The superadded keel, co-extended anteriorly with the connate manubrial process of the sternum of the Pterodactyle, plainly bespeaks, however, additional functions; but these might have been, as Herman v. Meyer suggests, the same as in the penguin, or even in the mole. And, at this point, the physiologist in quest of the locomotive relations of the sternum, would pass to the comparison of the humerus and other bones of the fore limb; or, failing those, to a more minute scrutiny of the texture of the breast-bone of the Pterodactyle. It is almost superfluous to remark that the evidence of the fore limbs had shown the Pterodactyle to have been a flying animal long before anything was precisely known as to its sternum.

The development of the interpectoral process or keel of the sternum in the Pterodactyle exceeds that in any of the bat tribe; and it may be confidently concluded that the flight of the winged reptile might have been, at least, as swift and of as long continuance as in the *Pteropi*. But, viewing the pneumaticity of the bones of the Pterodactyle, and the relatively greater and more continuous development of the interpectoral crest of the sternum, I am led to believe it to have been a creature of more extensive continuous, and powerful flight than is now enjoyed by any bat; and the Pterodactyles may at least have been as capable of migration as the great frugivorous *Chiroptera*. The structural affinities, however, of the Pterodactyles to the cold-blooded air-breathers, and their analogy, in wing-structure, to the bats, indicate that they might have possessed the faculty of becoming torpid, and of so existing during a period when their food in a given locality was not attainable.†

* From the appearances presented by the crushed specimen of *Pterodactylus Gemmingi*, imbedded in a slab of lithographic slate, I believe that the part of the sternum showing those articulations has been accidentally separated from the rest of the fractured bone. (See Von Meyer, Tab. x, op. cit.) The estimable author concludes that the marginal portion of sternum, with articulations with ossified sternal ribs, was originally distinct from the body or main plate of the sternum; but the plate of the specimen he describes shows fractures and some mutilation of the bones.

† The inferences from what was previously known as to the structure of the sternum of the Pterodactyle are thus expressed by M. H. v. Meyer, in his summary of the knowledge of the Pterosauria, in 1859: "Es zeigt keinen Kiel oder Gräthe, und man könnte daher glauben, dass, da die Stelle zum Ansatz eines kräftigen Flugmuskels fehlt, die Pterodactyln keine guten Flieger gewesen wären. In dem Mangel eines Kieles scheint indess nur eine Andeutung zu liegen, dass die Thiere keine Vögel waren. Eben so wenig werden sie Wanderthiere gewesen seyn, und bedurften daher auch keines so starken Brustmuskels. Das Brustbein der Fledermäuse gleicht sogar durch die Gegenwart eines Kiels mehr dem in den Vögeln.

In no other reptile does the sternum present coracoid articulations so shaped and so placed as in the Pterodactyle. The Crocodilia, in which, as in Pterosauria, the clavicles are wanting, show the broad, sternal margins of the coracoids ligamentarily attached to the middle of the lateral border of the sternum.

In bats the obtuse, sternal ends of the clavicles are applied to protuberances of the manubrium above the articulations of the first pair of ribs. Only in birds are distinct synovial articular cavities provided for the coracoids, which, in the main, are situated and shaped as in the Pterodactyle. The differences are these: the concavity and the convexity being (as *e.g.* in *Aptenodytes*) the same, the bent grooves so formed are much longer than in the Pterodactyle, with a concomitant greater expansion of the ends of the bones they firmly lodge. The coracoid grooves are divided by a non-articular, median depression in *Aptenodytes*, but this, in some other birds, is wanting, the coracoid grooves decussating across the middle line, *e.g.* in the Heron.* There are various minor modifications of the coracoid grooves in the breast-bone of birds.

The marked distinction in the breast-bone of the Pterodactyle is its compression behind the coracoid articulations, and the distinct commencement of the shield-like expansion behind that articular part.

In most birds the "manubrium" projects from the mid-space between the coracoid grooves, and is distinct from the "keel;" in some it is bifurcate; in the penguins it is as little developed as in the Pterodactyle, and is as directly continuous or connate with the forward production of the keel. In this production *Aptenodytes patachonica* most resembles, amongst birds, the Pterodactyle. The parts are homologous, and if we name that production the fore part of the keel of the breast-bone in the aquatic bird, we must apply the same name to it in the Pterodactyle; only in the latter the keel subsides sooner beneath the expanded part of the sternum.

In the Crocodilia the broad, thin, sternal borders of the coracoids are attached by fibrous substance to the fibro-cartilaginous, or, in old animals, partially

Es besitzen aber auch die Maulwürfe am brustbein diesen Kiel, der daher nicht unbedingt als ein Zeichen des Flugvermögens gelten kann; er setzt eigentlich nur starke Brustmuskeln voraus, die daran befestigt waren. Selbst in den Schwimmvögeln die nicht zu fliegen vermögen ist der Kiel vorhanden für starke Brustmuskeln, die hier zum Schwimmen eben so nöthig sind wie dem Maulwürf zum Graben. . . . . Aus diesen Betrachtungen ergiebt sich, dass der Pterodactylus nach der Beschaffenheit seines Brustbeins weder ein eigentliches Wasserthier, noch ein Gräber war, vielmehr ein Thier der Luft." ('Reptilien aus dem Lithographischen Schiefer,' &c., fol., p. 17.)

Professor Quenstedt, however, seems to me to have rightly appreciated the homology of the fore part of the sternum and the physiological deductions from it: "Der Kamm springt vorn einen halben Zoll weit über die Fläche des Knochens hinaus, gibt daher Beweis genug, das das Thier fliegen konnte." (Op. cit., p. 44.)

* Owen, 'History of British Fossil Mammals and Birds,' 8vo, 1846, p. 556, fig. 236.

ossified, plate, representing the sternum of struthious birds. The bony sternum, or "episternum," is long, narrow, and depressed; it is considerably produced in advance of the coracoids, but this produced part is flattened horizontally. If it be compared with the pre-coracoid part of the sternum in the Pterodactyle or penguin, it is not more like the one than the other. In the main, the Pterosaurian breast-bone, like the scapular-arch, is formed on the ornithic type, but the post-coracoid, lateral emarginations are distinctive Pterosaurian characters.

The Humerus of Pterodactylus (Pl. 13).

The fragile texture of the bones of the Pterodactyle, and the constantly crushed or broken state in which those of the wings more especially have hitherto been usually found, have precluded any precise description or figures of the articular surfaces, or of the configuration of the extremities of these bones. And yet such particulars are absolutely requisite for defining the resemblance of the Pterosaurian humerus to that of the bird and reptile, and for acquiring this element in the determination of the degree of affinity or relation of the Pterosauria to those classes respectively.

The remains of the very large species of Pterodactyle from the Cretaceous formations of Kent and Cambridgeshire have furnished materials for advancing this desirable knowledge in regard to the structure of the vertebræ,* and I have now similar means of contributing more precise information respecting the structure of the proximal end of the humerus than has hitherto been possessed. For the subjects of this study and comparison I am chiefly indebted to Professor Sedgwick. But, in proceeding to impart the results, I must premise some notice of the character of the humerus in birds, in which I shall avail myself of the terms indicative of aspect and position proposed by Dr. Barclay, in his 'Anatomical Nomenclature.'

Proximal signifies the upper, *distal* the lower, ends of the bone, as it hangs in man; *anconal* is the posterior, *palmar* the anterior, surface, as when the palm of the hand is directed forward; *radial* is the outer, *ulnar* is the inner, side, according to the same position of the human arm and hand. *Proximad*, *palmad*, &c., are adverbial inflections, meaning towards the proximal (upper) end, and towards the palmar (anterior) side.

In the bird, then, the humerus has a smooth shaft, subelliptic in transverse section, with expanded ends, the proximal one being the broadest. Lengthwise the bone is gently sigmoid, the proximal half being convex palmad, the distal half

* Pp. 385—390; and 'Phil Trans.,' tom. cit.

concave, with the plane of the terminal expansions vertical, as the bone extends along the side of the trunk from its scapulo-coracoid articulations backward, in its position of rest.

The head of the humerus is an elongate, semioval convexity (Pl. 13, fig. 8 *a*), with the long axis transverse from the radial to the ulnar sides (vertical, as naturally articulated), and with the ends continued into the upper (*b*) and lower (*c*) crests. Of these, the upper one (*b*, figs. 6—8), in the natural position of the bone, is on the same side as the radius, the lower, more tuberous one (*c*), is on the same side as the ulna; the one marks the " radial " side, the other the " ulnar " side, of the bone. The side of the humerus next the trunk answers to that called " anconal " (fig. 7), the opposite side to that called " palmar " (fig. 6).

The expanded, proximal part of the shaft on the palmar side (fig. 6) is concave across, convex lengthwise; on the anconal side (fig. 7) it is convex across to where the ulnar ridge (*c*) bends anconad near the pneumatic orifice beneath.

The radial crest (*b*) answers to the " greater tuberosity " and to the " pectoral " and " deltoidal ridges " in mammals; the " ulnar " crest (*c*) to the " lesser tuberosity," and the ridge for the " latissimus dorsi," in mammals.

In a few exceptions the shaft of the humerus is almost cylindrical, in still fewer (*e.g. Aptenodytes*) it is flat.

In the vulture (*V. monachus*), the ulnar crest forms a thick tuberosity at its proximal end (fig. 7, *c*), projecting anconad, and overarching the " pneumatic " foramen (*p*); it descends a short way obliquely palmad, decreasing in breadth, but still thick, convex, and terminating obtusely (fig. 6, *c'*). The radial crest (fig. 6, *b*) better merits the name; it extends twice the length of the ulnar one, down the shaft, to the palmar side, towards which the whole crest is slightly bent; its margin describes a very open or low, obtuse, angle at its middle part. A ridge (*r*) upon the palmar side of its distal half indicates the boundary of the insertion of the pectoralis major into the crest. At the middle of the anconal surface of the proximal part of the shaft there is a low, longitudinal ridge (fig. 7, *l*).

At the distal part of the humerus a ridge on the radial side of the palmar surface, and a rising of the bone on the ulnar side of the same surface, diverge to the opposite angles or tuberosities of the expanded end of the bone; they include a shallow, subtriangular concavity above the articular surfaces. These are two, and are convex.

The radial surface is a narrow, subelongate convexity, extending from near the middle of the palmar surface obliquely to the lower part of the radial tuberosity, where the convexity subsides; it is very prominent at its palmar end, with a groove on each side, the deeper one dividing it from the ulnar, articular convexity. This is of a transversely oval or elliptical shape, most prominent

palmad; all the part of the end of the humerus forming the two articular convexities is as if bent toward the palmar aspect. The ulnar end of the ulnar convexity is bent, and continued anconad to that end of the ulnar tuberosity. An oblique longitudinal channel divides the anconal end of the radial tuberosity from an almost longitudinal ridge, which is nearer the middle of the anconal side of the distal end of the humerus; a similar, but shorter, longitudinal ridge or rising of bone, terminates in the anconal part of the ulnar tuberosity. Between the above almost parallel ridges the anconal surface is nearly flat transversely; it is traversed along the middle by a low, narrow, longitudinal ridge. Lengthwise the bone is here convex.

The differences in the humerus of different birds are seen chiefly in the forms and proportions of the proximal crests; the radial one in the *Columbidæ, e.g.* is shorter and more produced than in most birds of flight. The humerus in the swift and humming-bird is distinguished by special modifications.

In the crocodile (Pl. 13, figs. 9—12), the articular head of the humerus (fig. 12, *a*) is a transversely elongated, sub-oval convexity; it is continued upon the short, obtuse, angular prominence (*c*), answering to the ulnar crest or tuberosity in the bird. The radial crest (fig. 9, *b*) begins to project from the shaft at some distance from the head of the bone; it is shorter, thicker, more prominent, and projects more directly palmad than in the bird. The humerus presents a similar sigmoid flexure lengthwise to that in the bird, but the ulnar contour of the shaft, as it descends from the ulnar end of the head of the bone, describes a concave line to the ulnar condyle; the radial contour is sigmoid, and not affected by the radial crest, as in the bird. There is a longitudinal ridge (fig. 10, *d*) on the anconal surface close to the radial border.

The humerus of the Pterodactyle (ib., figs. 1—5) is shorter in proportion to the expanse of its proximal end than in either the bird or crocodile, and it appears to have a straighter shaft. It conforms at its proximal end more with the Crocodilian than the Avian type. The ulnar crest, or tuberosity (*c*), is rather more prominent and better defined than in the crocodile, but the radial crest (*b*) is much more developed than in either the crocodile or bird. It resembles that of the crocodile in being more directly bent palmad, or what would be outward in relation to the side of the trunk, in the natural position of the bone at rest.

The crest begins, above, at the radial and palmar end or angle of the articular head of the bone, and rapidly expands, bending palmad, with a base co-extensive with one fifth of the length of the humerus, inclining, as it descends (fig. 3), to the palmar side, ending below by a rough tuberosity, *b*, projecting at a right angle from the shaft of the bone; the lower sharp margin (fig. 1, *b'*) of the tuberosity passes by a quick curve, and subsides upon the cylindrical shaft. The palmar surface of the proximal part of the humerus, by the production in that direction of the ulnar

tuberosity, but more especially by the direction of the large, radial crest (*b*), is more concave across than in birds. Between *b* and *c'*, in fig. 1, it is gently convex lengthwise, and is very smooth.

A longitudinal ridge (fig. 1, *r*), along the distal half and palmar side of the base of the radial crest, indicates, as in birds, the insertion of the strong and large pectoral muscle.

The articular head of the bone is reniform, not uniformly convex, as in birds, but slightly concave between the beginnings of the radial and ulnar crests or processes on that moiety of the head next the palmar side (fig. 3, *a*). At the opposite (anconal) side (fig. 2, *a*), the head-piece projects slightly beyond or overhangs the shaft, the upper part of which, on the anconal side, is slightly concave lengthwise, very convex across, more so than in birds, and without trace of the median longitudinal ridge (*l*, fig. 7). It is equally devoid of the ridge which, in the crocodile (fig. 18, *d*), runs close to the radial side of the anconal surface.

The shaft is more cylindrical than in birds. The pneumatic foramen (figs. 2, 5, *p*) is situated a little below the radial end of the head of the bone, on the palmar side of the bone; in the vulture, and most birds of flight, it is situated on the opposite side (fig. 7, *p*). The pneumatic texture of the shaft is as well marked as in any bird of flight.

In looking directly upon the palmar side of the humerus in the bird one has an oblique, foreshortened view of the radial crest, the base of which lies wholly along the radial margin. Taking the same view of the humerus of the Pterodactyle as in Pl. 13, fig. 3, we look almost directly upon the edge of the radial crest (*b*, *b'*), the base of which has inclined below from the radial upon the palmar surface. A corresponding view of the humerus of the crocodile (fig. 11) shows the whole base of the radial crest on the palmar surface, clear of the radial border, and the opposite side of the crest to that in the bird is obliquely brought into view. (In the figure 11 the radial side of the shaft is rather too much turned towards the eye.)

In the position and shape of the radial crest the Pterodactyle is between the bird and the crocodile; in the transverse extent of the crest it exceeds both. The crest differs in extent and shape in different species of the Pterodactyle. In fig. 1 the ulnar side of the shaft is turned so far towards the eye as to permit the whole breadth of the radial crest (*b*) to be seen. The degree to which the radial crest projected in the humerus of the large Cretacean Pterodactyle (Pl. 13, fig. 1) is only shown at its lower part, the upper, thinner portion being broken away. Relatively to the size of the head of the bone, the extent of the base is greater than in the smaller species of Pterodactyle, a corresponding portion of the humerus of which is represented in fig. 5, from the same aspect as fig. 1. The

extent of the base of the radial crests in fig. 5 corresponds with that of *Pterodactylus suevicus*.*

In *Ramphorhynchus Gemmingi* the radial crest, with a similar short origin, has a remarkable transverse extent, and expands at its termination, so that both upper and lower margins are very concave.† The latter is of much greater relative extent than in the large Cretaceous Pterodactyle (Pl. 13, fig. 1). The Wealden Pterodactyle (*Pter. ornis*) resembled *Ramphorhynchus* in the proportions of the radial or outer process (*g*, fig. 5, 'Quart. Journal of the Geol. Soc.,' 1845, p. 99).

The determination of the homologies of the processes from the proximal end of the humerus of the Pterodactyle with those in the bird and crocodile enables one to recognise the specimen (figs. 1—3 and fig. 5) as part of the right humerus.

Fig. 4 is part of the left humerus, from the Upper Green-sand and Cambridgeshire, but was drawn upon the stone without reversing, to facilitate its comparison with fig. 1, from the Middle or White Chalk of Kent, which it resembles in the extent of origin of the radial ridge (*b*).

Carpal Bones (Pl. 12, fig. 6; Pl. 14, figs. 5—9).

The two bones (*Pterosauria*, Pl. 14, figs. 5, 6, and figs. 7—10) correspond in size so much more with that of the distal extremities of the radius and ulna than with that of the same part of the tibia, as to leave a conviction that they are carpal bones, and they afford instructive evidence of the characters of those bones in the Pterodactyle. Specimens of more or less entire, but dislocated, skeletons of the smaller kinds of Pterodactyle from Oolitic strata, especially that of *Pterodactylus suevicus* from the lithographic slates of Wirtemburg,‡ and that of *Ramphorhynchus Gemmingi* from the same formation at Eichstadt,§ have demonstrated the presence of at least two large carpal bones, with one or two smaller ones, the two carpals forming a first and second row; but the figures are two small and indefinite to permit the matching with them of either of the larger and probably better-preserved carpal bones from the Cambridge Green-sand.

The first to be described in subdepressed, subtriangular in shape, with a general tendency to convexity on one articular surface (Pl. 14, fig. 8), and to concavity

* Quenstedt, op. cit., tab. i, *cr*, *cl*.

† H. v. Meyer, op. cit., tab. ix. A. Wagner, 'Fauna des Lithogr. Schiefers,' 4to, 1858, taf. xvi.

‡ Well described and figured by Professor Quenstedt, in his treatise 'Ueber *Pterodactylus suevicus*,' 4to, Tubingen, 1855.

§ H. v. Meyer, op. cit., tab. ix, fig. 1.

on the opposite surface (fig. 7); but both these surfaces are irregularly undulated, as shown in the figures; the more concave surface being also impressed by a deep hemispheric pit. I conjecture that this bone formed the proximal part of the carpus, and that the pit may have received a process of the distal end of one of the antibrachial bones. The opposite, probably distal, and more convex surface (fig. 8) is divided into two slight convexities, by a shallow, wide channel, crossing the bone obliquely. The convexity (*a*) meets the concave surface on the other side of the bone (*e, f*) by their convergence to the basal border or margin, which presents a slight notch. The opposite end of the bone forms the obtuse apex (*d*), which is a little bent down towards the concave side. On this side (fig. 7) the notch is continued into an angular channel, which divides the two shallow, concave surfaces (*e* and *f*) occupying the basal half of this surface; a little nearer the apex than the middle of the bone comes the hemispheric pit, with a small depression on one side of it.

Fig. 9 shows the thickest or deepest, non-articular side of the bone, sloping to the end of the facet (*f*), and with the apical tuberosity (*d*) at the opposite end.

Fig. 10 is taken looking upon the convex surface from the notched base (*a*).

Fig. 8 may correspond with the surface of the carpal bone in *Pterodactylus suevicus*, marked 1, in the bones of the left wing in Professor Quenstedt's Plate; and the side view of the same bone in the carpus of the right wing gives an indication of the produced apex. The outline of the large proximal carpal in *Pterodactylus* (*Ramphorhynchus*) *Gemmingi*, in M. v. Meyer's Plate, accords in a general way with the profile of the narrower side of the present bone, which, for the convenience of indication and description, might be called the "scapho-cuneiform." I have no proof, however, from knowledge of its precise connexions, of the accuracy of this determination, but strongly suspect that the bone may represent more than one of the proximal carpals in the mammalian wrist, and probably the two proximal bones in the carpus of the crocodile.

In Pl. 12, fig. 6, a scapho-cuneiform bone is figured, which, from its size, might belong to *Pterodactylus simus;* it differs from that in Pl. 14, fig. 7, not merely in size, but, apparently, in a greater relative breadth of the surfaces (*e* and *f*); their margins forming the base of the triangle have been, however, abraded.

The second large wrist-bone (Pl. 14, figs. 5 and 6), if the foregoing be rightly compared, will match with the carpal bone articulating with the proximal end of the metacarpal of the fifth or wing-finger in the plates of *Pterodactylus suevicus*, and of *Ramphorhynchus Gemmingi*, above cited; and it will consequently answer to or include the "unciforme," by which name it will be here described and figured.

Both proximal and distal surfaces show well-defined, concave articulations. On the more concave surface (fig. 5) there is an oblong, articular depression (*g*), continuous at the margin (*h*) with a surface on the opposite side of the bone; a more irregular undulated channel, deepest at the middle part (*i*), occupies the rest of the surface, but the end of the bone opposite (*h*) has been broken away. Fig. 6 shows two shallow, articular channels (*k* and *l*), partly divided near the end (*h*) by a tract of non-articular surface.

In birds the base of the metacarpal of the digitus medius has the "os magnum" connate therewith, it also becomes confluent with the bases of the second and fourth metacarpals. Between this compound bone and the antibrachium two distinct carpal bones partially intervene, being wedged between the metacarpus and antibrachium, one on each side. The Pterodactyle, in the complete separation of the metacarpus from the antibrachium, by two successive carpals, answering to the two rows, adheres more closely to the Reptilian type; but differs in the much greater expanse and complexity of the carpals, and in their minor length.

Ungual Phalanx (Pl. 14, figs. 11 and 12).

The ungual phalanx (*Pterosauria*, Pl. 14, figs. 11 and 12), accords in size with that of the limb indicated by the carpal bones (figs. 5—10). The articular surface presents two trochlear concavities, extended vertically, narrow transversely, divided by a median ridge; the upper angle is rather produced; below the trochlea is a small depression, and below this the bone projects in the form of the rough protuberance for the flexor tendon. On each side of the phalanx is the curved vascular groove, beneath which, in some specimens, the bone slightly expands. In one specimen a second, more shallow groove is shown on one side, nearer the upper margin of the bone.

SUPPLEMENT NO. I.

CRETACEOUS ENALIOSAURS.

ORDER—*SAUROPTERYGIA, Owen.**

Genus—POLYPTYCHODON, *Owen.*

POLYPTYCHODON INTERRUPTUS, *Owen.*

In Chapter III, on Fossil Reptilia of the Chalk Formations, pp. 209—212, certain dental and osteological characters of a large extinct Saurian were described and figured, confirmatory of the distinct generic form of reptile, for which had been proposed the name *Polyptychodon*,† having reference to the numerous longitudinal ridges and grooves, giving a minutely folded surface to the enamel covering the crown of the tooth. In my 'Report on British Fossil Reptiles,' the genus was referred to the 'Sauria incertæ sedis,' no other parts save the teeth being then (1841) known. A few years later a portion of jaw was discovered in the Lower Chalk of Kent, showing that the teeth were implanted in distinct sockets, as in the *Crocodilia*. This specimen I described and figured in the work of my friend, Mr. Dixon, entitled 'The Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex.'‡

Some large fossil bones from a Green-sand quarry near Hythe, Kent, described in the above-cited chapter, p. 201, as probably belonging to *Polyptychodon*, showed that "the pubis and ischium approached somewhat to the Plesiosaurian type."

Cranium and Teeth (Pl. 14, figs. 1—3.

I have lately been favoured by Mr. George Cubitt with the inspection of part of the cranium, including portions of jaws with teeth, of *Polyptychodon interruptus*, discovered in cutting a railway tunnel through the Chalk formations near Frome, Somersetshire, which gives further evidence of the Plesiosauroid affinities of the genus, in the presence of a large oblique "foramen parietale" between the frontal and parietal bones (*Enaliosauria*, Pl. 14, fig. 1, *p*).

* 'Report of the British Association,' 1859, p. 153.

† This genus was established, on the characters of detached teeth from the Chalk, in the author's "Report on British Fossil Reptiles," 'Trans. of the British Association,' 1841, p. 156.

‡ 4to, 1848, tab. xxxviii, fig. 3.

The parietal bone (7) is much compressed, and develops a sharp and rather lofty median crest behind the foramen (*p*), which crest divides the temporal fossæ (*t*, *t*). Behind this crest the parietal bone expands transversely, and assumes a tri-radiate form, the two transverse rays uniting with the mastoids (8, 8). These are very powerful bones, bounding the outer and back part of the temporal fossæ; they are smooth and slightly convex above, rough and slightly concave at the back part near the angle, where a surface is thus formed for the attachment of some powerful muscle. The part of the mastoid which curves forward from the angle to form the back part of the zygomatic arch becomes compressed, and terminates above in a ridge (*r*). The substance of the mastoid is extensively excavated, apparently for the upper part of the acoustic chamber.

The frontal bone (11) is overlapped behind by the parietal, and appears to have been divided by a median "harmonia," or smooth suture; the receding halves of the frontal behind, as they pass beneath the parietal, form the fore part of the foramen parietale. The back part of the foramen is formed by a notch in the fore part of the single and undivided parietal. The canal from the foramen extends obliquely downward and backward. The long diameter of the foramen is 1 inch; the breadth of the back part of the cranium is 16 inches; the breadth of the back part of each temporal fossa is $6\frac{1}{2}$ inches. The power of the muscles acting upon the lower jaw must have been very great.

A portion of a symmetrical bone, 10 inches long, which formed the upper median part of the face, anterior to the orbits, represents part of an undivided nasal bone (15), and shows that bone to have been long, narrow, straight longitudinally, convex transversely above, as if the upper part of the face had been traversed by a low, obtuse, median rising.

In most of these characters may be discerned a closer affinity to the Plesiosauroid than to the Crocodilian type.

The expanse of the temporal fossæ equals that in the *Plesiosauria* and *Teleosauria*, but no species of the latter genus of *Crocodilia* has presented the "foramen parietale," whilst it is a constant character in the *Plesiosauria, Ichthyosauri*, and *Labyrinthodontia;* many of the modern lizards also present the same foramen. The portion of the upper maxillary bone, figured of the natural size at fig. 2, Pl. 14, shows the same obliquity of the separate sockets of the teeth as exists in those at the fore part of the bone in certain *Plesiosauri*, and the small separate foramina (*o*, *o*), at the inner and back part of the large alveoli, which had been perforated by the summits of the successional teeth, are of plesiosauroid character. I have seen portions of jaws of *Plesiosaurus megacephalus* in which the appearance of a double row of teeth was caused by the length of the protruding summits of the new teeth before they displace the old when they are pushed, causing absorption of the intervening osseous bar, into the large sockets of the teeth they replace.

The crown of the teeth of *Plesiosaurus* is, moreover, one which that of the teeth of *Polyptychodon* (fig. 3) resembles in the ridged enamelled surface and subcircular transverse section; but the teeth of true *Plesiosauri* are proportionally longer and more slender, whilst those of *Polyptychodon* in the proportions of the crown more resemble the teeth of the crocodilian genera *Goniopholis* and *Madrimosaurus*.

The microscopic structure agrees equally with the plesiosauroid and crocodilian modifications of the dental tissues. In Pl. 14, fig. 3, *b* shows the shape of the base of the deeply implanted tooth, at the part where it had been broken in one of the specimens (*a*), accompanying the portion of cranium from the Lower Chalk at Frome. Fig. 3 is a more entire tooth of the same individual.

Cervical Vertebra (*Enaliosauria*, Pl. 31, figs. 1 and 2).

I next proceed to offer other evidences tending to show the affinity of *Polyptychodon* to *Plesiosaurus*. In the Upper Green-sand deposits near Cambridge and in the Neocomian formations of similar age at Kursk, south of Moscow, large vertebræ of the Plesiosauroid type have been discovered, together with teeth of *Polyptychodon*, which vertebræ I believe to belong to that genus.

The centrum of a cervical vertebra, from the Cambridgeshire Upper Green-sand (figured in *Enaliosauria*, Pl. 31, figs. 1 and 2), measures 4 inches 3 lines in length, 5 inches 3 lines across the terminal articular surface, and 7 inches in total breadth, including the transverse processes (*pl*, *pl*). Each of these projects about an inch from the side, rather nearer the fore than the back part, of the vertebra, and terminates in a flattened surface for the ligamentous articulation of the cervical rib, which surface measures 2 inches 3 lines by 2 inches in its diameters (fig. 1, *pl*). The articular surfaces of the centrum are nearly flat.

This vertebra, with which no other teeth save those of *Polyptychodon*, from the same formation and locality, agree in size, thus presents the essential characters of the neck-vertebræ of *Nothosaurus* and *Plesiosaurus*, and must be referred to the order *Sauropterygia*.* The specimen is preserved in the Woodwardian Museum at Cambridge. It was obtained from the Green-sand phosphatic-nodule works at Haslingfield, about four miles from the town of Cambridge.

In a collection of Upper Greed-sand fossils from the vicinity of that town, lately purchased by the British Museum, there is the centrum of a dorsal vertebra of corresponding dimensions. It presents the usual characters of the Plesiosauroids; the articular ends are very slightly concave, with a moderate prominence in the middle, of a subcircular form, about the size of a crown-piece. The sides are gently concave lengthwise; the under surface is so in a less degree; this non-articular

* See the "Classification of Reptilia," 'Reports of the British Association,' 1859, p. 159, and Owen's 'Palæontology,' 8vo, 1860, p. 209.

surface is smooth at the middle part, with longitudinal, irregularly wavy ridges and grooves for an inch at the margin, which are well defined; this roughness indicates the attachment of the fibres of the capsular ligament. The fore-and-aft diameter of the centrum is less at the summit than at the base; here it measures 4 inches 6 lines; along the neural canal it is 4 inches; the smooth tract caused by the impress of this canal is 6 lines across the narrowest part, and 2 inches across the widest end. The neurapophysial pits are shallow, with a rugged surface 3 inches 6 lines long by 1 inch 9 lines in diameter; the small part of the upper surface of the centrum not covered by the neurapophysis is at the end where the neural canal is widest, and which is most probably the hinder end; there are two venous foramina on one side and three on the other side of the middle of the lower surface of the centrum. The breadth of the articular surface is 6 inches 3 lines; its depth, or vertical extent, the same.

The same conformity, in regard to their proportional size, characterises the teeth of *Polyptychodon* and the associated large Plesiosauroid vertebræ from Kursk. I am indebted to the able engineer and zealous palæontologist, Colonel Kiprianoff, for the opportunity of examining the specimens discovered by him in that locality.

The centrum of one of these vertebæ belonging to the dorsal region, from the Neocomian formations at Kursk, measures 4 inches in length and 5 inches 4 lines in breadth; the terminal articular surfaces are flat; between them the lower surface of the centrum is straight, but at the sides it is gently concave; there are two venous foramina, 2 lines apart, at the middle of the under surface of the centrum.

Portions of ribs from the Upper Green-sand of Cambridgeshire agree in texture, and correspond in proportional size, with the cervical and dorsal vertebral bodies with which they were associated. I have selected one of these fragments for representation in Pl. 31, fig. 3, because it shows a well-marked ridge (*s*) on one side, a character I have not seen in the ribs of true *Plesiosauri;* and these portions of ribs, of probably *Polyptychodon*, present a less rounded transverse section.

Atlas and Axis (*Enaliosauria,* Pl. 32).

The centrums of the first and second cervical vertebræ coalesced, as in *Plesiosaurus*, from the same locality and formation as the hinder cervical vertebra, p. 457, Pl. 31, present the proportions, in regard to their antero-posterior diameter, of the cervical vertebræ of *Pliosaurus*; but they belong, in all probability, to the same Plesiosauroid reptile as the vertebræ previously described, and I refer them to the genus *Polyptychodon.*

Like most of the fossils from the Haslingfield locality, they had been subject to attrition. The contour of the centrum of the atlas (*Enaliosauria,* Pl. 32, fig. 1) has been subcircular; its anterior articular surface (*c, a,*) is concave, and has afforded

a large proportion of the bottom or middle part of the cup for the occipital condyle. The lower part of the cup has been completed, as in *Plesiosaurus*, by a wedge-shaped hypapophysis, the articular surface for which is shown at *h, y*; the upper contour has been contributed by the neurapophyses, the articular surfaces for which may be discerned at *n, p*, on each side of the smooth neural tract, *n*, in figs. 2 and 3.

The line of the original separation of the bodies of the atlas and axis may be traced; the second hypapophysis, or part of it, remains anchylosed to their inferior interspace; it has been much smaller than the first. The posterior surface of the centrum of the axis vertebra (fig. 2, *c, x*) is almost flat, showing the Plesiosauroid nature of the bones. In the similarly short vertebræ of an Ichthyosaurus this surface would have been deeply concave.

Having thus a proof of the plesiosauroid nature of these anchylosed vertebræ, the same grounds for referring them to *Polyptychodon* apply as to the posterior cervical vertebræ (Pl. 31, figs. 1 and 2) of more ordinary plesiosaurian proportions. Between that vertebræ and the axis I infer, therefore, that the anterior cervicals rapidly diminished in length, and that the anterior ones exhibited the same Ichthyosaurian shortness as they do in *Pliosaurus*. The magnitude of the head, jaws, and teeth, of *Polyptychodon* resembled that of its more ancient congener from the Kimmeridge Clay, and the supporting part of the spinal column appears to have been shortened and strengthened accordingly.

It is probable that the large Plesiosauroid paddle, from the Chalk of Kent (p. 220), the phalanges of which are figured in '*Enaliosauria*,' Pl. 30, belonged to *Polyptychodon*. Thus the evidence at present obtained respecting the huge but hitherto problematical carnivorous Saurian of the Cretaceous period proves it to have been a marine one—the rival and contemporary of the equally huge Maestricht lizard (p. 183). But whilst *Mosasaurus*, by its vertebral, palatal, and dental characters, foreshadows the saurian type to follow, *Polyptychodon* adheres more closely to the prevailing type of the sea-lizards of the great geological epoch then drawing to its close.

The seas in which the English Chalk hills and cliffs were formed, and by which they were modified in the course of upheaval, must have teemed with life, and have been traversed by shoals of fishes needed for the sustentation of the numerous kinds of large marine reptiles now known to have existed during that period, and all of which were provided with jaws and teeth adapted, under diverse secondary modifications, to the capture and destruction of the finny races. Of these carnivorous reptiles some, as *e.g. Ichthyosaurus campylodon* (p. 223) and *Plesiosaurus Bernardi* (214), were large species of genera represented throughout the oolitic period; others, as *e.g. Leiodon* (p. 195) and *Mosasaurus* (p. 183), offer generic or family modifications of the Saurian structure, unknown in any other than the Cretaceous

deposits. The subject of the present section, as gigantic as the Maestricht *Mosasaur*, manifests an extreme modification of the Plesiosauroid type of structure. It is probable that the large Pterodactyles of the same geological period, soaring like albatrosses and giant petrels over the Cretaceous seas, co-operated with the marine reptiles, as those sea birds now do with cetaceous mammals, in reducing the excessive numbers of the teeming tribes of fishes, and in maintaining the balance of oceanic life.

SUPPLEMENT NO. I.

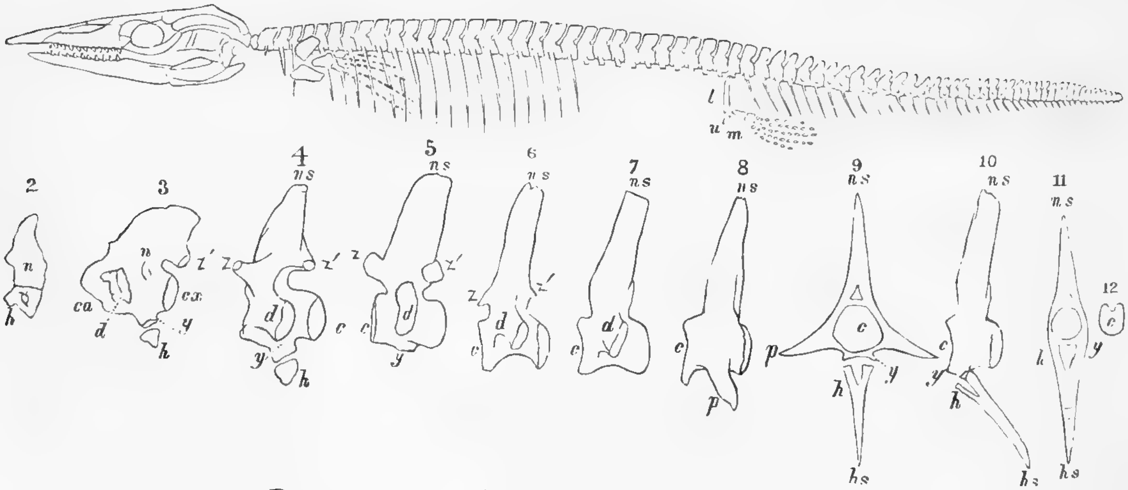
CRETACEOUS LIZARDS.

Tribe—NATANTIA.

The genus *Leiodon* was defined (p. 195) on a modification of Mosasauroid teeth in a fragment of jaw discovered in a Cretaceous formation in Norfolk.[1]

The vertebral column of *Leiodon anceps* (Cut, fig. 1) exhibits the range of modification in its several regions which I deem to be characteristic of the great extinct

FIG 1.



RESTORATION AND TYPE-VERTEBRÆ, LEIODON ANCEPS.

'*Lacertia natantia*,' and offers a strong contrast with the comparative uniformity of the vertebræ in *Python*, *Palæophis* and other *Ophidia* (pp. 135—154).

The atlas (fig. 2) consists of a pair of neurapophyses, *n*, and a detached hæmapophysis, *h*, simulating a centrum: of this the transverse exceeds the vertical

[1] See 'Report of the British Association' for 1841, 8vo., p. 144.

diameter, although the latter is extended by a short obtuse hypapophysial spine, less developed than in *Mosasaurus*. Each neurapophysis presents a large sub-concave facet for articulating with part of the occipital condyle.

The axis (fig. 3) consists of a long body, including the proper centrum of the atlas, *c a*, coalesced with that of the axis, *c x*. The latter develops a hypapophysis, *y*, to which is articulated a short hæmapophysis, *h*. A compressed vertical ridge-like process (par-diapophysis, *d*) extends from each side of the centrum; it may be for the support of a rudimental cervical rib.

A few of the succeeding vertebræ are characterised by both diapophysis (fig. 4, *d*) and hypapophysis, *y*—the latter with a rough articular surface for ligamentous attachment of a hæmapophysis, *h*.

The diapophysis of the third cervical supports a rib; and a similar costigerous process is present in the dorsal vertebræ. This series may be conveniently, though artificially, defined by the suppression of the hypapophysis. The zygapophyses (figs. 5 and 6, *z z'*) disappear in the posterior dorsals as in fig. 7. The diminution in vertical and increase in longitudinal extent, together with a descent in position from the side of the centrum, reduce the transverse process to a parapophysis, *p*, fig. 8, which characterises the lumbar vertebræ.

The centrum here becomes triangular, in transverse section, with the base downward. There is no 'sacrum' by ankylosis; it is represented by a single vertebra supporting a pair of small rib-like *ilia* (fig. 1, *b*). The pubis, *u*, is slender, nearly straight; the ischium, *m*, is broader, with a short hind process, offering a syndesmosal surface for the ilium and the femur; it also unites with its fellow, completing the inverted 'pelvic arch' below. The following table gives the kinds and numbers of the vertebræ.

		Number.
Atlas and axis		2
Vertebræ	(type 4) with hæmopophysis, hypapophysis, diapophysis, and zygapophysis	5
,,	(type 5) with hypapophysis, zygapophysis, and diapophysis	7
,,	(type 6) with zygapophysis and diapophysis	18
,,	(type 7) with diapophysis	22
,,	(type 8) with parapophysis	15
,,	(type 9) with parapophysis and unankylosed hæmal arch	24
,,	(type 10) with unankylosed hæmal arch	14
,,	(type 11) with ankylosed hæmal arch	44
,,	(type 12) with centrum and neurapophyses, the latter rudimental or none	12
		163

The vertebræ of *Leiodon* are devoid of the accessory zygantral and zygosphenal articulations. In the few Mosasauroids which show them they adhere to the iguanoid type (Ophidia, Pl. 2, figs. 34, 35).

All the ribs or pleurapophyses, where present or preserved, are monocipital. In *Leiodon* the basisphenoid is concave, almost canaliculate along the middle of the under surface, devoid of any ophidian median ridge; the pair of hypapophyses abut against the pair from the basioccipital, but leave the broad truncate ends of these free, as in *Amblyrhynchus.*

In *Leiodon*, as in *Mosasaurus*, there is a large 'foramen pineale' which, as in *Monitor*, is wholly in the parietal. This bone bifurcates posteriorly; its prongs extend backward, outward, and articulate with the mastoid, which curves outward and downward to join the squamosal, and, with it, forms the articular surface for the tympanic. Anteriorly the squamosal unites with the postfrontal, 12. The long and wide temporal fossæ are bounded, externally, as in Lacertians, by a long and narrow zygomatic bridge, in the composition and proportions of which *Leiodon* most resembles the Monitors and Iguanas.

Leiodon, like other Mosasauroids, has two pairs of limbs, of the natatory type; the tegumentary sheath is supported by five digits, in both fore and hind fins. The phalangeal formula is, in the main, Lacertian (fig. 1).

In the single occipital condyle and the composite structure of the mandible the Mosasaurians are *Reptilian;* in the procœlian vertebræ they accord with the existing representatives of the class; in the double occipital hypapophyses, in the bifurcate and perforate parietal, in the columella, in the composite formation of the suspensory joint of the tympanic, in the type of the tympanic, in the frame of the parial nostrils, in the composition of the mandible, and in the structure and attachment of the teeth they are *Lacertian;* in one special dental modification they are *Iguanian;* in another they are *Monitorial.* In the broad cemental basis of the enamelled tooth, in the more extensive fixation of the pterygoids and ossification of the roof of the mouth, in the large proportion of the vertebral column devoid of zygapophyses, in the confluence of the hæmal arch with the centrum of certain of the caudal vertebræ, in the natatory character of the fore and hind limbs, they are *Mosasaurian.* But they do not seem to me to be entitled, through the last category of modifications, to the rank of an order in the reptilian class.

The order Lacertilia, in the class Reptilia, is a taxonomic equivalent of the order Carnivora or Feræ in the mammalian class.

In the Feræ there is a group which, by modifications of the skull, teeth, vertebræ, and, especially, limbs, takes rank as a suborder or subordinate group, viz. the Pinnipedia or Phocidæ. I estimate the Mosasaurians in the Lacertian order to be equivalent to the Seals in the Ferine order.

ORDER—PTEROSAURIA.

PTERODACTYLES OF THE LIASSIC FORMATIONS.

Genus—DIMORPHODON, *Owen.*

Species—DIMORPHODON MACRONYX, *Buckland.*

REMAINS of volant Reptiles (*Pterosauria*) were later recognised, and, save in the instance about to be recorded, in a more fragmentary or scattered condition, in England than in Continental localities.

A single bone or tooth gives value to a slab of Stonesfield Slate, and the evidence of a Pterodactyle rarely goes beyond such specimen in that Oolitic deposit. A jaw with teeth, or a skull more or less entire, from the Chalk of Kent, or the Upper Green-sand of Cambridge, has been welcomed for the fuller information so yielded; and such fossils, with a few detached vertebræ and wing-bones, have expanded our conceptions of the bulk attained by some of the Flying-dragons at the decline of the Mesozoic period.

When the waters over which they flitted had a clayey or muddy bottom it afforded a quieter resting-place to the dead body of the Pterosaurian therein entombed. So the first discovered specimen of one of these in the upraised petrified ocean-bed now forming the Liassic cliffs of western Dorsetshire afforded BUCKLAND[1] subjects, in the compass of a slab about a foot square, for a description and figures of the leg and wing-bones, with part of the vertebral column, of the species which he called *Pterodactylus macronyx*—the first evidence of the genus from deposits so low, or ancient, in the Oolitic series.

In 1858 I obtained the skull, with a few other parts of the skeleton of the same or a closely allied species, from the Lower Lias at Lyme Regis, and communicated a brief notice of it to the British Association, which that year met at Leeds.[2]

[1] "On the Discovery of a New Species of Pterodactyle in the Lias at Lyme Regis." By the Rev. W. Buckland, D.D., F.R.S., F.G.S. (Read Feb. 6, 1829.) 'Transactions of the Geological Society of London,' second series, 4to, vol. iii, 1835, p. 217, pl. xxvii.

[2] "On a New Genus (*Dimorphodon*) of *Pterosauria*, with Remarks on the Geological Distribution of Flying Reptiles;" in 'Reports (Sections) of the British Association,' 1858, p. 97.

This specimen confirmed the accuracy of Buckland's conjecture, which I had doubted, viz., that the portion of lower jaw with the series of small lancet-shaped, close-set teeth,[1] in a second slab of Lias, belonged to the same Pterodactyle as the limb-bones he described; but it also showed that these teeth, so like those of some Fishes, were limited to the lower jaw, and were associated, in the same mouth, with long, slender, trenchant and sharp-pointed laniaries, projecting with wide intervals, and set in advance; which kind of teeth had, hitherto, alone been found in the different species of flying Reptiles.

The chief result of the study of the second discovery of a Pterosaurian in Lias, viz., its evidence of a new generic form (*Dimorphodon*) in the order of volant *Reptilia*, in addition to *Rhamphorhynchus*, von Meyer, and *Pterodactylus* proper, was noted in the communication above cited.

The third specimen about to be described confirms that taxonomic deduction, showing a combination of the caudal character, mainly differentiating *Rhamphorhynchus* from *Pterodactylus*, with the dental character above defined.

I propose first to describe and figure the two specimens yielding the cranial and dental characters of *Dimorphodon*, and then to attempt a restoration of the Liassic species, *D. macronyx*.

The first specimen with the skull is figured in Pl. 15. It is on a slab of Lias, measuring 11 inches by 7 inches. The right side of the head is exposed:[2] it has been subject to pressure and some degree of dislocation. Certain bones of both wings, and a few other parts of the skeleton are preserved, pell-mell, in this slab, pressed amongst and upon the bones of the head, especially at the back part of the skull.

The right premaxillary (22), maxillary (21), and nasal (15), are almost in their natural positions, give the profile contour of that part of the skull, show most of the teeth of the right side upper jaw, and reveal the singular expansion of the nasal (*n*) and antorbital (*a*) vacuities. The alveolar part of the left maxillary (8'), with its ascending postnarial branch has been pushed obliquely downward, with fracture, but without much displacement, of the beginning of the alveolar ray, the inner surface of which is exposed.

The mandible (32) has been dislocated and pushed below the place of its articulation with the tympanic (28): the left ramus has also been subject to the same force which has dislocated that side of the upper jaw; the hind part of this ramus is obliquely depressed, so as to expose the inner surface (32).

The anterior entire or undivided part of the premaxillary (22) is about 2 inches in length, and $1\frac{1}{4}$ inch in vertical height at its back part: it contains four pairs of teeth, which are the largest and longest of the series. The foremost tooth (1) is terminal, with a crown 5 lines in length, rather over 1 line in breadth (fore-and-aft) at its base; it is subcompressed,

[1] Buckland, loc. cit., pl. xxvii, fig. 3.

[2] The specimen has been drawn, in Pl. 15 (*Pterosauria*), without reversing.

subrecurved, and sharp-pointed. An interval of 4 lines divides it from the second tooth (2), with a crown $5\frac{1}{2}$ lines long. After an interval of 7 lines projects the crown (3) of the third tooth, 7 lines in length and 2 lines in basal breadth, sharp-pointed like the first, but less bent. The socket and base (?) of the fourth tooth appear at an interval of 6 lines, and below is the entire and displaced homotypal tooth (4′) of the left side, showing the cavity on the inner side of its root which would have received the successional laniary. This tooth measures 1 inch 2 lines in total length, of which the exposed enamelled crown forms two-thirds. In advance of the foremost tooth (1) is seen part of its homotype (1′) of the left side, also displaced from the socket, and showing the depression and vacuity on the inside of the base, in relation to the succeeding tooth. Beyond the fourth alveolus the maxillary (21) appears, underlapping the part of the premaxillary (22″) which defines the lower and anterior part of the narial vacuity: the maxillary is continued straight backward, with feeble indications of two crushed alveoli (5, 6) for 1 inch 9 lines, when the seventh laniary (7) projects almost straight downward: the crown of this tooth is 5 lines long; the root, covered with rougher cement, slightly contracts to its implanted end, which has slipped a short way out of its socket. An interval of 4 lines divides this from the next laniary (8), which shows a crown of but 3 lines in length; this projects opposite the fore part of the lateral post-narial branch (21^{x}) of the maxillary. The base of the left homotypal tooth (8′) projects from the same part of the dislocated left alveolar branch of the maxillary; and above this, on the inner side of that bone, is exposed the coronal germ of a successor. In the right maxillary two other straight laniaries (9, 10) of rather decreasing length, project with similar or rather lessening intervals: then follows, after an interval of 3 lines, a pointed compressed crown $1\frac{1}{2}$ line in length (11); and, at shorter intervals, two smaller pointed compressed teeth (12 and 13).

These thirteen cuspidate teeth of the upper jaw are included in an extent of the alveolar border measuring 5 inches 2 lines. That border is continued backward, straight and edentulous, for 9 lines beyond the last tooth, when it is crossed by the large and long first phalanx ($_{IV}$ 1) of the wing-finger. This edentulous part of the maxillary forms the lower straight border or base of the large triangular antorbital vacuity (*a*), at the back part of which it is overlapped by the fore part of the slender malar (26). Above this vacuity are parts of the nasal (15) and prefrontal (14), both somewhat displaced in this crushed part of the skull. The arched part of the frontal forming the upper part of the rim of the orbit (*o*) is recognisable at (11) Pl. 15. Above its hind part are indications of the post-frontal (12) and mastoid (8), with the process of the latter descending external to its articulation with the tympanic (28). The metacarpus and dislocated unguiculate digits of the wing-limb are confusedly interblended with the crushed and dislocated back part of this skull; three phalanges (*IV* 1, *IV* 2, *IV* 3) of the wing-finger are determinable.

The two anterior teeth (1′, 2′) of the mandible show longitudinal angular depressions at their base, indicating exposure of their inner side, and that they belong to the left ramus. The corresponding part of the right ramus may have been broken away: the third laniary

(3′) clearly belongs to this ramus, which is fractured beneath its socket. The point of this tooth is broken off: what remains of the body is curved, and is implanted more obliquely backward than the two preceding teeth. This at first led me to suspect it might be the foremost tooth of the mandible, and that the left ramus had been pushed in advance as well as downward: but my doubts on this point have been set at rest by the specimen (Pl. 16) next to be described, and I view the tooth in question as the third of the mandibular series: it is divided from the second by an interval of 6 lines, and the second stands at a rather shorter interval behind the first. Five lines behind the third tooth is the base of a fourth laniary (4′), and four lines further back is an indication of a fifth (5′). This is followed by the characteristic series of between thirty and forty very small, subcompressed cuspidate teeth, each less than a line in length, corresponding in extent with the maxillary part of the upper jaw. The entire series of mandibular teeth occupies an extent of alveolar border measuring 5 inches 1 line.

The depth of the right ramus gradually increases from 5 lines below the last laniary to 10 lines below the last denticle. The inner side of the dislocated ramus (32′) shows a strong longitudinal ridge projecting inwards about 3 lines above the lower border. The outer surface of the ramus seems to have been strengthened near its lower border by a similar but lower ridge.

The distal ends of the antibrachial bones (54, 55) overlap the hind part of the mandible: that which shows the larger articular surface, opposite the three slender metacarpals, should be the radius. The base of the supplementary styloid bone appears near the distal end of the ulna, but is better shown in Buckland's original specimen. Indications of two carpals intervene between these and the metacarpus. This overlies and conceals the articular pedicle of the mandible and contiguous parts (squamosal, malar, &c.) of the skull. The metacarpus includes the three slender supports of digits *I, II,* and *III*, and the strong and thick metacarpal of the wing-finger (*IV*). This bone, being almost concealed by the first phalanx in Buckland's specimen, was overlooked, and that phalanx was described as the metacarpal of the wing-finger, which, accordingly, in the restoration, fig. 2, Pl. 27, of 'Buckland's Memoir,' is made three times the length of the other and more slender metacarpals (3′). In the original specimen, now in the British Museum, the true metacarpal may be distinctly traced. It corresponds with the same bone in previously described *Pterosauria* by surpassing in thickness, not in length, the other constituents of the metacarpus. In the specimen, Pl. 15, the metacarpal of one wing-finger is clearly shown at *IV m.* That of the other, lying upon the cranium, is more obscure. The thin compact wall of this pneumatic bone has been crushed in upon the wide air-cavity, as with most of the other long bones, so that it looks like two metacarpals. The proximal articular surface of *IV m* is partly concave and partly convex: the distal articulation is trochlear, moderately concave from side to side at the middle, convex from behind forward, with a depression behind, above the articulation, for securing the olecranoid process of the proximal phalanx. This phalanx (*IV*, 1), in one

wing, is bent back upon the fore-arm, crosses the dislocated mandible, and has been pressed upon it, long and hard enough to leave a channel in the right ramus, where part of the phalanx has been removed: its length is 4 inches 6 lines.

The second, more slender and longer phalanx ($_{IV,}$ 2), is bent at nearly a right angle with the first, and lies below and parallel with the mandible: it is nearly 5 inches in length. The third phalanx ($_{IV,}$ 3) is bent upward in front of both lower and upper jaws: 4½ inches of its length is preserved in the slab: from the analogy of the better preserved specimens (Pl. 16, *IV,* 3), about 1 inch 3 lines are wanting from the distal end.

Of the three unguiculate digits the characteristic large claws are preserved: one ($_{II}$) lies above the frontal (11) with the penultimate phalanx; the other two are between the upper and lower jaws, with some of the slender phalanges: all these parts of the ramus having been dislocated and scattered.

Parts of the distal ends of the radius and ulna (54′, 55′), the metacarpal of the wing-finger ($_{IV\,m'}$), and the proximal end of its first phalanx ($_{IV\,r'}$), of the opposite fore-limb, occupy a lower corner of the slab: carpal bones, one of the accessory styloid ossicles of the forearm, some of the slender metacarpals of the claw-fingers can be made out above these: and there are more obscure indications of vertebræ at that end of the slab, curving toward the cranium.

All the osseous and dental textures are black, as if charred by slow combustion of the animal matter.

Dimorphodon macronyx. Pl. 16.

In August, 1868, I was favoured by the Earl of Enniskillen, then at Lyme Regis, Dorsetshire, with a list of parts of a Pterodactyle, in a slab of Lias about 20 inches by 11 inches, and of other parts in detached portions of Lias, including the entire tail with its bone-tendons, which his Lordship had observed at Messrs. James and Henry Marder's, the judicious and persevering collectors of the fossils of that rich locality.

The result of this valuable and timely information was the securing for the British Museum the entire series of these Pterosaurian fossils.

They proved to be parts of the *Dimorphodon macronyx*, confirmed many of the observations made on previously acquired specimens, corrected others, and added almost all that was required for the restoration of the skeleton of this remarkable genus and species, which I have accordingly attempted in Pl. 17 (*Pterosauria*).

The slab of Lias with the second specimen, including the skull of *Dimorphodon macronyx*, is of larger size, shows more of the skeleton and in a more separated and definable state

than in Pl. 15. Nine dorsal vertebræ, third to eleventh inclusive, in natural juxtaposition, with the twelfth slightly dislocated, are preserved at the upper part of the slab (Pl. 16, D). The summits of the neurals pines (*ns*) of most of these, and the disposition of many of the preserved ribs, show that they lie mainly with the dorsal aspect downward (as the specimen is figured). This explains and accords with the position of the parts of the pelvis, which lie a little way behind the dorsal vertebræ. The comparatively slender ilium ($_{62,\,62}$) is downward; the broad ischium ($_{63}$), and the pair of spatulate pubic bones ($_{64}$), are turned, like most of the ribs, upward, as I conclude the abdominal or ventral surface of the trunk was directed as the fossil lies in the figured slab. The bones of the hind-limb, in connection with the acetabulum, are turned outward, with their inner surface exposed. The projections of the trochlear terminations of the metatarsals (*i*, *iv*, $_{69}$), show that the sole of the foot is turned to view. Accordingly, we have here the bones of the left hind limb. On the hypothesis that the femur and tibia are seen from the outside, which at first suggests itself, they would belong to the right limb, viewed in profile. But then, the broad thin plate of bone contributing to the acetabulum, would represent the ilium, and the indications of the pelvis below the acetabulum and head of the femur would represent ischium and pubis. This interpretation, however, gives to *Dimorphodon* proportions of pelvic bones very different from those determined by Wagner in *Pterodactylus Kochii*,[1] and by Quenstedt[2] in *Pterodactylus suevicus;* and, besides, it leaves undetermined the pair of bones (64, Pl. 16) which closely resemble in form and proportion the 'pubic bones' (*u*, *u*) in Quenstedt's instructive plate.[3] In this plate the ilia (*s*, *s*) are represented as long slender bones, contributing the upper but smaller proportion of the acetabulum, and extending horizontally beyond it both forward and backward. The pelvis, in the position in which I conclude it to lie in the slab figured in Pl. 16, might well afford such indications of the pre- and post-acetabular productions of the ilium as are there shown at $_{62,\,62}$. In *Pterodactylus suevicus* the ischium contributes the lower and major half of the acetabulum (*tr*, loc. cit.), and expands into a broad thin plate (*s*, ib.), having the proportions to that of the spatulate pubis, which the bone $_{63}$ bears to $_{64}$, in Pl. 16. The portion of the pelvis in the original specimen is preserved in natural connection with the sacrum and contiguous vertebræ; and the constituent bones are rightly recognised by Buckland (op. cit., p. 222).

It is interesting to note, that the pelvis of *Pterosauria*, so determined, resembles more closely that of the existing representatives of the section of *Reptilia* with the 4-chambered heart and double-jointed ribs, viz., *Crocodilia*, than it does the pelvis in *Chelonia* and *Lacertia*. The ischium in *Crocodilia*, *e. g.*, surpasses the pubis in size, and excludes that

1 "Ueber *Ornithocephalus Kochii*," in 'Abhandl. d. math.-phys. Klasse der Bayerischen Akad.,' ii, 4to, München, 1837.

2 'Ueber *Pterodactylus suevicus*,' &c., 4to, Tübingen, 1855.

3 In the Memoir above cited.

hæmapophysis from the acetabulum.[1] The ischium seems to contribute the larger share of the acetabulum in *Dimorphodon*, Pl. 16, *a*. In Birds, as in Lizards, the pubis forms part of the acetabular cavity.[2]

In the specimen, Pl. 16, a portion, *cd*, of a long tail, of which the vertebræ were surrounded by numerous slender bone-tendons, extends backward and downward beyond the pelvis: a better preserved portion with three caudal vertebræ (*c d'*) is preserved in a detached part of the matrix found in the vicinity of the larger slab. But to this part of the vertebral column I shall return in describing the more perfect specimen of the tail of *Dimorphodon*, from another individual.

Behind the skull are four cervical vertebræ (Pl. 16, c), and part of a fifth in natural juxtaposition, or perhaps a little separated at the articular surfaces. The under surface of the centrums and articular processes of the neural arches are exposed. The sides of the centrums show a slight concavity, but their crushed state obscures the natural contour of the under surface. The hind part of the under surface, in the last two of these vertebræ, shows a pair of low obtuse processes, with an indication of a convex terminal articular surface. The centrum expands in breadth as it advances, and sends out a short thick process (parapophysis) from each side of the fore part; to which, in the last three vertebræ, are indications of attachment, or parts, of a backwardly produced styliform rib. At the midline of the fore part of the last two of these vertebræ a fracture indicates a ridge or process there to have been broken off. The pre-zygapophyses are thick, and project far in advance of the concave anterior articular surface of the centrum: the convex posterior articular surface of the centrum projects as far beyond the post-zygapophyses. Their joints are more vertical than horizontal: the posterior surfaces looking slightly outward and downward.

The superior breadth of the neural arch, as compared with that of the centrum, brings its articular processes into view, along each side of the vertebral bodies, in the degree shown in Pl. 16, c. The character of the articulations indicate less extent and freedom of movement of the cervical vertebræ than in Birds, and more restriction in the lateral than in the vertical directions. The interlocking joints resulting from the different lengths of the fore and hind articular processes add strength to the part of the spine supporting the head.

The cervical vertebræ of *Dimorphodon*, so far as their structure is exemplified in the present specimen, conform to the pterosaurian characteristics of these vertebræ, as shown in those of *Pterodactylus Sedgwickii*, described (p. 382), and figured in Pl. 7, figs. 7—18; and in those of *Pterodactylus simus* (p. 437, Pl. 11, figs. 1—5).

The skull preserved in the present specimen agrees in size with that in the slab previously received (Pl. 15), repeats the characteristics of the genus *Dimorphodon*, and shows no

[1] 'Anatomy of Vertebrates,' vol. v, p. 188, fig. 119.

[2] Ib., p. 190.

differences of greater degree or value than may be set down to individual modifications. The part defective and partly obscured by intrusive bones from other parts of the skeleton is unfortunately that which leaves the precise determination of structure unsatisfactory in the previously described specimen. A trace only of tympanic remains at 28, and of the descending styloid process of the mastoid at 8: the thick metacarpal of the wing-finger (iv, *m*), intrudes into the orbit, and overlaps the upper end of the malar (26). More of the part of the frontal forming the superorbital arch (11) is shown than in Pl. 15. Part of the concave surface of the orbital cavity beneath the superciliary ridge is here seen. The lacrymal (23) or descending branch of the prefrontal (14) meets the ascending process from the combined malar and maxillary, dividing the orbital from the antorbital cavity. The true size and shape of the latter vacuity (*o*) is here well displayed. The maxillary styloid process (21ˣ) rises, at the same angle backward as in Pl. 15, to join the nasal (15). The medial branch or ray of the premaxillary (22′), the end of which is depressed below the prefrontal in Pl. 15, preserves its position in the present specimen, and yields the true arched contour of the profile of this remarkable skull.

The entire vertical extent of the vast narial vacuity, *n*, is here given, the longitudinal one, 3½ inches, precisely agreeing with that in the first-described skull. The anterior part of the premaxillary (22) shows, also, the same proportions and shape, viewed sideways, as in the first specimen.

The conformity is instructively continued in the characters of the dental system. The apex of the crown of the laniary (Pl. 16, 1) from the fore end of the premaxillary shows the same curvature and proportions as in Pl. 15; the same interval divides it from the second laniary (2); the longer interval, again, occurs between the second and the third laniary, with a longer and less curved crown. After an interval of seven lines comes the fourth tooth (4), corresponding in size and shape with the one which is displaced in Pl. 15, 4′. After an interval of nine lines the apex of the crown of, seemingly, the successor of the fifth laniary (5) appears. It may be, normally, smaller than the rest; the socket of this tooth is feebly indicated in the subject of Pl. 15. The sixth laniary (6) shows the same size and relative position as in that subject, and the same may be said of the five succeeding teeth, save that the last is rather larger than in Pl. 15, which also shows an additional small hind cuspidate tooth. The suture between the premaxillary (22″) and the maxillary (21) is more plainly discernible in the present specimen.

The extent of alveolar surface of the left upper jaw occupied by the above-described dental series is 5 inches 3 lines.

In the left ramus of the mandible two of the large anterior laniaries are in place; one, answering to the second in Pl. 15, 2′, projects across the diastema between the second and third tooth above; in size, shape, and curvature, it resembles the second upper laniary, close to which it terminates. The next mandibular tooth is larger, less curved, and crosses the middle of the interval between the third and fourth upper laniaries. The tooth (1′)

displaced beneath the mutilated fore part of the mandible, I take to be the foremost of the mandibular series and suppose that its point would naturally project across the interval between the first and second of the upper teeth. The fourth laniary appears to be more displaced: its base or root, with a lateral depression, is shown behind the fifth tooth of the minute serial teeth, and the crown passes obliquely backward on the inner side of that of the sixth upper laniary, by which it is concealed. Of the serial teeth, with pointed crowns from half a line to a line in length, about thirty may be reckoned occupying an alveolar extent of 2 inches, 9 lines.

At the hind part of the left mandibular ramus, here exposed, three longitudinal ridges define two vacuities, of which the inferior may be natural. The upper one seems more plainly due to loss of the thin outer plate of bone extended between the upper two ridges. The proportions of the ramus closely accord with those of the first-described specimen. The fore part of the mandible is too much mutilated for useful comparison.

The dentition of *Dimorphodon,* as displayed by the second specimen of skull, consists, in the upper jaw, of laniaries with wide intervals, eleven in number on each side; in the lower jaw, of four, if not five, laniaries implanted at the fore part of each ramus of the mandible at intervals corresponding with three of the four anterior laniaries above; then follows the long series of close-set and minute pointed teeth. The difference of dentition as compared with the first specimen (Pl. 15) is, in the upper jaw, in the additional small laniary or cuspidate tooth at the back part of the series in that specimen. In the lower jaw there does not seem to be any noteworthy difference in the number, kinds, and position of the teeth. The longest laniaries are included between the second and fifth in both jaws: the upper laniaries after the fourth become small and straight.

At the first view of the framework of the huge head of our Liassic dragon one is struck with the economy of bony material and the purposive skill with which it has been applied or disposed, so as to give strength where resisting power was most required.

The lodgment of the poorly developed brain enlists a miserably small proportion of the skull: the cranium proper, or brain-case, is relegated to an out-of-the-way corner, so to speak, and there it is almost concealed by the projections for joints or muscular attachments. The orbits accord with the large eyes given to this volant and swift-moving Reptile.

One can conceive no necessary interdependent relation between the wide external bony nostril (*n*) and the organ of smell, nor be led to conjecture that the tegumentary inlets to the nasal chamber were larger than is usual in Reptiles.

The main purpose of the head is for prehension of prey. The jaws are produced far forward to form a wide-gaping mouth, and are formidably armed. We may conceive, therefore, that the dragon may have occasionally seized an animal of such size as to

require considerable force of jaw for overcoming its struggles. The means of resistance were afforded to the upper or fixed maxilla, not by a continuous wall of bone, but by curved columns or abutments. The chief of these is the upper medial arch of bone which overspans the skull lengthwise, from the short roof of the cranium to the fore part of the premaxillary (22); the frontals (11) and nasals (15) combining with the mid-fork or branch of the premaxillary (22',) to constitute this arched key-ridge of the roof of the head.

From it two piers or buttresses out-span on each side, to give strength and resistance to the upper jaw, and especially its alveolar tracts. One, proceeding from the nasal, meets the uprising process of the maxillary (21); this abutment, curving from above outward and obliquely forward, expands and backs the part of the jaw where the second group of large laniaries project. The second buttress is continued from the prefrontal (14), and arches more directly outward to meet the uprising process of the malo-maxillary. A third arch, due to the post-frontal (12) and malar (26), expands to abut upon the hind end of the maxillary arch, and gives support to the part of the skull which the temporal muscles tended to pull downward when they were giving to the mandible the power of a strong bite or grip. Finally, comes the strongest of the four piers, due to the mastoid (8) and tympanic (28), for giving articular attachments to the rami of the lower jaw.

Thus, four vacuities appear in the side-walls of the skull: the first (n) is the largest, between the small consolidated or continuous fore part of the skull (22), and the naso-maxillary pillar (21^x, 15). This vacuity answers to the external bony nostril of the same side, in the Lizard's skull (Pl. 17, fig. 3, *n*), where the nostrils are divided and more or less lateral. The second vacuity (a) is somewhat less, of a triangular form, with the base downward: it answers to the antorbital vacuity in *Lyriocephalus* (ib., *a*) and a few other Lizards, and to that in *Teleosaurus*, where, however, it is very small. The third vacuity (o) still decreasing, is oval, with the narrow end or apex downward: it answers to the orbit, but is of large size compared with most Saurians; it is, however, exceeded in relative expanse by the orbit in *Lyriocephalus* (ib., *o*).

The fourth vacuity is the narrowest: it answers to the so-called 'temporal fossa' and was occupied by the muscles of the same name. Extension of surface, for their origin, and additional strengthening of this back part of the skull are gained by laying horizontally across the temporal fossa the bony beams called 'upper and lower zygomata,' arching from the postfronto-malar to the masto-tympanic vertical columns. The heavy phosphate of lime, thus singularly economised by the disposition of the bones on mechanical principles plainly to that end, is made to go still further by the arrangement of the osseous tissue. Every bone is pneumatic, the abundant, open, cancellous structure being included in a very thin layer of compact osteine.

The bones of the limbs are dislocated and dispersed in the way and degree common to the specimens of this animal hitherto discovered (Buckland, loc. cit., pl. xxvii; and pls.

15 and 16 of the present Monograph). The scapula (Pl. 15, 51) and coracoid (ib., 52) in the same anchylosed condition as in the first-described specimen, are at the end of the slab opposite to that with the head. The corresponding humerus (53), preserved in a separate portion of the block of Lias, shows the entire contour of the pectoral process (*b*). The right humerus (53′) lies below the dorsal vertebræ (D); the upper part of the pectoral process (*b*) is wanting, but the obtuse thickening of the end of that remarkable production is well shown. The ridge (*c*) called 'ulnar,'[1] descending from the 'lesser tuberosity,' appears in this view of the 'palmar' surface of the bone.[2] The sigmoid flexure of the shaft is much better marked than in the humerus of *Pterodactylus suevicus*.[3] The stronger walls of the humerus have resisted the pressure better than those of most of the other long bones.

Of the antibrachial bones parts of the shafts, crushed, are seen at 54, 55, apparently of the right wing. With the distal ends of these, the right carpus (56) and metacarpus (57) appear to have retained their natural connections. The slender metacarpals of the first (I), second (II), and third (III) digits appear emerging from beneath the left hind foot which overlies their proximal ends. The phalanges of the first digit (I), two in number, preserve their natural articulations. As are also those of the second digit, three in number. The metacarpal of this digit is longer by $2\frac{1}{2}$ lines than that of the first. The additional phalanx would seem to be the proximal one, by its shortness: the second phalanx more nearly agrees in length with that supporting the claw-phalanx in the first digit; but it is thicker and a little longer. The four phalanges of the third digit (III) are dislocated; but the penultimate, which is the longest, retains its connection with the ungual phalanx. The proximal phalanx is longer than the second, which resembles in length, and seems homotypal with, the proximal phalanx of the second digit. It may be concluded, therefore, that the additional phalanx to II and III was developed at the attachment of the digit to the metacarpus. The largely and abruptly expanded metacarpal of the fourth digit is in great part covered by the correspondingly thickened and much elongated phalanx ($_{IV,}$ 1) therewith articulated. The olecranoid process of this phalanx is well shown, and the entire bone is preserved: its length is 4 inches 2 lines: it is bent directly and abruptly back upon its metacarpal. To the distal end is attached part of the second phalanx ($_{IV,}$ 2).

The proximal phalanx of the left wing-finger is preserved in a detached ($_{IV,}$ 1) part of the slab (Pl. 16) containing the major part of the skeleton. The second phalanx ($_{IV,2'}$) of the left wing-finger lies in that slab, is entire, and yields a length of 4 inches 9 lines. The third phalanx ($_{IV,3}$) is 5 inches 6 lines in length; near its distal end is part of the slender terminal phalanx of this digit ($_{IV,4}$). There is no trace of a fourth unguiculate digit, and I return to

[1] P. 449, pl. 13, fig. 1, *c*.

[2] P. 451.

[3] Quenstedt, op. cit., *c l*, *c r*.

Cuvier's view of the structure and homologies of the hand of the Petrodactyle,[1] which I had abandoned in favour of the seemingly more perfect evidence supporting Professor Goldfuss' restoration of *Pterodactylus crassirostris*,[2] adopted by Buckland[3] and myself.[4]

The metacarpal of the left wing-finger ($_{IV, m'}$, Pl. 16) lies beneath the back part of the skull, and is over-lapped by the superorbital part of the frontal. Portions of two of the unguiculate digits of the same fore-paw ($_{I, II}$) are seen in the wide narial vacuity.

The definition and finish, so to speak, of the joints of the wing-finger are worthy of note, especially of that between the metacarpal bone and proximal phalanx. In Reptiles generally the articular extremities of the long bones are not very definitely sculptured, and do not manifest that reciprocal adaptation of their inequalities which are observed in the joints of Mammals and Birds. The difficulty of determining the coadapted extremities of detached bones of Reptiles is increased by the great thickness of the cartilage which covers them and renders their mutual contact more intimate, and which is always wanting in fossil bones. The Pterosaurian modification is, however, purely adaptive; and the relation to Warm-blooded Vertebrates in this respect is one of analogy. An argument in favour of avian affinity from the joint-structures could only be propounded by one not gifted with the judgment needed to deal with problems of this nature.

The left femur (65′) preserves its natural articulation with the acetabulum; the head is bent forward from the line of the shaft for an extent like that at which the condyles are produced backward; the shaft is straight, the great trochanter is feebly developed. There is no evidence of a modification of the distal condyle for the interlocking articulation with the fibula, which in Birds relates to their bipedal station and walk. The length of this femur is 3 inches 4 lines

The left tibia (66′), bent back at an acute angle upon the femur, measures 4 inches 10 lines in length. There is no trace of patella, nor has this sesamoid bone been found in any Pterosaur. The inner side of the bone being exposed, the styliform rudiment of the fibula is hidden from view. The trochlear termination of the distal end of the tibia is better marked than in *Crocodilus*, or even than in *Scelidosaurus* ('Monograph on Oolitic Reptilia,' Palæontogr. Soc., Vol. for 1863, p. 16, Pl. X, 66), and consequently approaches more nearly to the characteristic form of the joint in Birds. The resemblance to the bicondyloid termination of the femur is instructively shown in the distal portion of every Pterosaurian tibia, as may be appreciated in the distal half of the right tibia of *Dimorphodon*

[1] 'Ossemens Fossiles,' 4to, v, pt. ii, p. 371.

[2] Beiträge zur Kentniss verschiedener Reptilien der Vorwelt, in 'Nova Acta Acad. Natur. Curios.,' Leopold Carol., &c., 4to, tom. xv. "Reptilien aus dem lithographischen Schiefer, *Pterodactylus crassirostris*, nobis, tabs. VII—X."

[3] 'Bridgewater Treatise,' 8vo, 1836, pl. 22.

[4] Owen's 'Palæontology,' 8vo, 1861, fig. 97.

in the slab, Pl. 16, at 66, which crosses the right antibrachium (54, 55). The deflected posterior ends of the condyles are here shown, and beneath them three tarsal bones (*o*, *l*, *b*), with the characteristic short and thick metatarsal of the fifth toe (*m*, *v*).[1]

The tarsal bone between the tibial trochlea and the three metatarsals (*i*, *ii*, *iii*), answers to the astragalus, marked *a*, in *Scelidosaurus* and *Crocodilus* (Monograph and Plate above cited); two tarsals, of which the one representing the second row is the smallest, intervene between the tibia and the fifth metatarsal; the larger of these ossicles answers to the calcaneum (*l* in *Scelidosaurus* and *Crocodilus*, Monograph, *ut suprâ*), the smaller and distal one to the cuboides (*b*, *ib.*).

The bony frame-work of the left foot (69′) is instructively preserved; the first four metatarsals are, as usual, long and slender, and resemble those in previously described *Pterosauria;* their under or plantar surface is exposed. The metatarsal of the first or innermost toe (*i*) is the shortest, that of the fourth toe (*iv*) is next in length; the third (*iii*) is the longest, but there is little difference in this respect; their distal condyles project toward the sole, and are made trochlear by a mid-groove.

The innermost digit shows the proximal and ungual phalanges in natural connection with each other and with the metatarsal: the ungual phalanx (*i*) is scarcely half the size of that of the corresponding digit (*I*) of the fore-foot. The ungual phalanges of the three other toes (*ii*, *iii*, *iv*) are preserved, showing the usual uniformity of size in the hind-foot of *Pterosauria:* the number and disposition of the contiguous but scattered phalanges best accord with the phalangeal formula (3, 4, 5) presented by the second, third, and fourth toes respectively, in better preserved feet of other *Pterosauria.*

There may be seen unequivocal evidence of a fifth toe, and that not merely rudimental but recognisably functional though without a claw. The tarsal bones (Pl. 16, *b*, *b*) support a metatarsal (*m*, *v*) directed parallel with the metatarsals (*i*—*iv*), but much shorter and also thicker: it is 6 lines in length, and expanded at both ends, the proximal one being $2\frac{1}{2}$ lines in breadth, the distal one 2 lines, and the middle of the shaft $1\frac{1}{2}$ line. The under or plantar side of the bone is exposed, as in the others, and shows a shallow oblique channel passing from the proximal end obliquely to the inner side of the shaft, dividing two elevations at that aspect of the proximal end. The distal end is a moderately convex condyle, the outer and plantar prominence of which is broken off. I regard this bone as the fifth metatarsal. It supports a digit of two phalanges: the first (1, *v*) is slightly dislocated, so as to show the concavity of its proximal joint close to the condyle to which it was articulated: it is 1 inch 3 lines in length, and is thicker as well as much longer than the corresponding phalanx of the other toes. The second phalanx (2, *v*) is 1 inch in length: it is bent back upon the first, and gradually tapers to a point. Both phalanges,

[1] This throws expository light on the idea, revived by Gegenbaur ('Vergleichend-anatomische Bemerkungen über das Fussskelet der Vögel,' in Reichert's 'Archiv für Anatomie, Physiologie, und wissensch. Medicin,' 1863, p. 445), viz., that the distal trochlear epiphysis of the Bird's tibia represents its proximal tarsal series, or astragalus.

in the specimen described, pass obliquely across and beneath the four long metatarsals supporting the unguiculate claws.[1]

From the position of this exunguiculate long and slender toe, as well as from its difference of structure, we may infer its application to a different office from that of the other toes. These obviously subserve the purposes of terrestrial locomotion, and perhaps of suspension: the fifth toe I infer to have helped to support, like the similarly shaped production of the calcaneum in certain Bats, the interfemoral expansion of alar integument, in the way indicated in the restoration (fig. 2, Pl. 17) of *Dimorphodon macronyx*. In the habitual mode of locomotion by vigorous act of flight this toe would be in action while the other four were at rest; hence the necessity for greater thickness and strength of its bones, and the size of one of the tendons, as indicated by the groove in the metatarsal. Interesting, also, is it to note the analogy of this 'wing-toe' with the 'wing-finger,' though they be not homotypes, as shown in the shortness as well as thickness of the metapodial bone and the length of the pointed, clawless, terminal phalanx.

The fourth slab of Lias adding to our means of reconstruction of *Dimorphodon*, was observed by the Earl of Enniskillen in the collection of Henry Marder, Esq., M.R.C.S., of Lyme Regis. It had been quarried from the same cliff as the preceding specimen (Pl. 16), and displayed the vertebræ and bone-tendons of a long and stiff tail (Pl. 17, c*d*.).

Indications of such a tail, in which the vertebræ were associated with ossified tendons, were apparent, and have been noted in the description in the second specimen with the skull (Pl. 16, CD); whereby one was able to show that the vertebræ in the originally described specimen supposed to be cervical (Buckland, loc. cit., pl. xxvii, *a*, *a'*) were truly caudal, with similarly associated bone-tendons, as, indeed, *Von Meyer* had recognised after the discovery of the caudal structure of his *Ramphorhynchus*.[2] The specimen now to be described of the entire tail, as represented by its petrifiable parts, I conclude, from the identity of character of some of its vertebræ with the three shown in Pl. 16, *c d'*, and from the discovery of this specimen in the same formation and locality, to belong to *Dimorphodon macronyx*.

The series of caudal vertebræ, to judge from the size of the anterior ones, comes from an individual as large as that represented by the fossils in Pls. 15 and 16, and, no doubt, from an adult or full grown one. This series is 1 foot 9 inches in length, following the curve, which is single and slight; and it includes upwards of thirty vertebræ. These vertebræ, 3

[1] "Cuvier, Wagler, und Goldfuss lassen den Fuss aus fünf ausgebildeten Zehen bestehen; in allen Pterodactyln habe ich aber nie mehr als vier solchen Zehen und höchstens noch einen Stummel vorgefunden." Von Meyer, op. cit., p. 20. But see 'Ossemens fossiles,' 4to, tom. v, pt. ii, p. 374—"Le cinquième réduit à un léger vestige," &c.

[2] "Beiträge zur näheren Kenntniss fossiler Reptilien," in Leonhard und Bronn's 'Neues Jahrbuch für Mineralogie,' &c., 8vo, 1857, p. 536.

lines in length of centrum in the first five, progressively increase to a length of 1 inch at the twelfth, begin to shorten gradually after the fifteenth, the twenty-first being 11 lines, the twenty-fourth 9 lines, the twenty-eighth 6 lines, and the thirtieth 5 lines in length. In breadth or thickness the vertebræ decrease from the first to the tenth; and then again gradually from the fifteenth to the last, which is filiform.

The first caudal, or the first of the series here preserved, has the anterior articular surface of the centrum subconcave. The inferior surface describes a slight concavity lengthwise; the upper part of the anterior half projects as a parapophysis, the end of which has been broken off, showing the open cancellous structure. A ridge from its upper part was continued to the fore part of the anchylosed neural arch. This arch developed zygapophyses, of which the anterior extend beyond the centrum; but they are better shown in succeeding vertebræ.

In the second caudal the base of the parapophysis has receded and now projects from the upper part of the side of the centrum, occupying more than its middle third. Part of a quadrate spinous process is here preserved, projecting above the centrum as far as the vertical diameter of that element.

In the third caudal the base of the parapophysis, reduced in vertical thickness, occupies the same positions and longitudinal extent. The postzygapophysis, after a deep hind notch of the neurapophysis, curves over the prezygapophysis of the succeeding vertebra, which enters that notch.

In the fourth caudal the base of the parapophysis has lost in longitudinal as well as vertical extent, and is more posterior in position. The subconvexity of the hind articulation of the centrum is here well shown. The confluent neural arch is low, attached to rather more than the fore half of the centrum. The postzygapophysis does not extend back beyond the centrum; the prezygapophysis is continued beyond the front or concave surface of the centrum into the neural notch of the preceding vertebra.

In the fifth caudal the parapophysis is smaller and more posterior. The neurapophysis rises from the anterior half of the side of the centrum and continues to show the zygapophysis, though reduced in size. Between the fifth and sixth caudals a small, slender hæmapophysis (*h*) has been articulated to the under part of the intervertebral space.

The reduced parapophysis is continued from the sixth caudal; this vertebra shows a much reduced indication of neurapophysis. The base of a hæmapophysis crosses the lower part of the space or joint between it and the seventh caudal, then expands both forward and backward, and more so in the latter direction; the inferior border of this expansion is straight.

In the seventh caudal the prezygapophysis is still indicated, though much reduced in size. The hæmapophysis, similar in shape to the preceding one, is longer; and three bone-tendons rise from the side of the hind projection of this hæmal arch.

In the eighth caudal the base of a reduced parapophysis projects from the side of the

centrum behind its middle; a low prezygapophysis projects from the neural arch: but beyond this vertebra all trace of that arch disappears, or is indicated by feeble prominences in the fasciculus of bone-tendons which seem to be attached to neural processes of the non-clongated centrums. Six or seven filamentary bone-tendons, one thicker than the rest, extend lengthwise above the centrum. Some of these may be traced over two centrums, then end in a point, their place being taken by another bone-tendon beginning by a similar pointed end. The parapophysis disappears in the tenth vertebra.

The caudal vertebræ in the first discovered specimen of *Dimorphodon*[1] answer to the eighth—eleventh in the present series. The elongate centrums of the tenth and succeeding caudals, usually more or less uncovered by the bone-tendons, show a low lateral ridge, and a slight expansion at the ends. The hæmapophyses are traceable, much reduced in size, to the fifteenth—sixteenth vertebræ. The bone-tendons are in two fasciculi, one neural, the other hæmal, in position. From five to eight may be counted in the side view given of each of these fasciculi. The seeming increase of thickness of some, usually the more peripheral of the filaments, may be due to this flattened form, and to more or less of the side coming into view, instead of the edge. Five or six may be counted in each fascicule, even beyond the twentieth caudal; the number varying at parts through the formation of the bundle by successive tendons, as above mentioned. They are reduced to two or three at the thirtieth vertebra. The terminal joints of the elongate centrums appear to be flattened and closely adapted, allowing of very little motion. It is evident that, as in *Ramphorhynchus*, the tail was stiff as well as long, and doubtless served as a sustaining ray of the parachute of membrane continued backwards from the wings and hind limbs.

The vertical diameter of the second caudal showing its neural spine is five lines. The diameter of the ninth vertebra, including the neural and hæmal fasciculi of bone-tendons, is the same; and beyond this the vertebræ and their surroundings gradually diminish to the pointed end of the tail.

§ Restoration of Dimorphodon. Plate 17.

The several parts of the skeleton of *Dimorphodon* preserved in the slabs of Lias described and referred to in the foregoing pages have ultimately yielded the desired result of their scrutiny and comparison, viz., a restoration of the extinct animal, such as I have endeavoured to exemplify in Plate 17; and I propose to apply that plate in illustration of a summary of the osteology and dentition of *Dimorphodon*, comparing therewith the

[1] Buckland, loc. cit., pl. 29, *a*, *a*. I have had these vertebræ carefully redrawn, from the specimen, in Pl. 17, *cd*.

previously known *Pterosauria*, and adding such deductions as to the status and affinities of the order as seem legitimately to flow from the facts.

The first distinguishing feature of *Dimorphodon*, or of the present liassic type of the genus, is the disproportionate magnitude of the head—the more strangely disproportionate, as it seems, in an animal of flight.

The head is large in proportion to the trunk, not only in respect of length but of depth, and probably, also, breadth; nevertheless, the shape and disposition of the constituent bones are such that, perhaps, no other known skull of a vertebrate is constructed with more economy of material—with an arrangement and connection of bones more completely adapted to combine lightness with strength.

So far as the skulls of *Pterosauria* have been sufficiently entire to show the shape of the head, no other known species resembles *Dimorphodon*. The cranial part is singularly small: the rest is mainly devoted to the formation of the large, long, and powerful prehensile and manducatory jaws. Among the débris of the cranial bones, in specimens Pls. 15 and 16, the mastoid (8), parts of the occipital (paroccipital, 4), the parietal (7), post-frontal (12), frontal (11), prefrontal (14), and nasal (15), are recognisable: the last two bones, however, are concerned more with the scaffolding or buttressing of the upper jaw than with the protection of the brain or formation of its case. Though contributing their shares to the otocrane, the chief developments of the paroccipital (Pl. 17, 4) and mastoid (ib. 8) relate to the muscular connections of the head with the trunk: the mastoid joins the postfrontal to form an upper zygoma, giving origin to part of the temporal muscles; it also affords a fixed articulation to the tympanic, and sends down a pointed process external to the masto-tympanic articulation. The parietals (Pl. 17, 7), confluent at the mid line, where they develop a low crest, swell out slightly at the temporal fossa, indicative of the size and saurian position of the mesencephalon. The frontal (11) is narrow and flat between the orbits, of which it contributes most of the upper part of the rim. This is continued by the postfrontal (12) behind, which sends down a long pointed process to unite with the malar (26), and a shorter and thicker one to join the mastoid (8). The prefrontal (14), of a triangular form, contributes to the upper and fore part of the orbit, and, either directly or by a connate lacrymal, unites with the ascending malo-maxillary process (21, 26), and the base of the prefrontal articulates with the frontal and the nasal. The nasals (15), to the usual connections with the frontal, prefrontal, and medial process of the premaxillary (22′), superadd a union with the lateral ascending process of the maxillary (21^{x}), completing the bar between the nostril (*n*) and the antorbital vacuity (*a*). The nasal bone forms the upper part of the nostril; the rest of the boundary of that singularly wide aperture is formed by the premaxillary and maxillary. Of the basis cranii and palate there do not appear to be any recognisable parts preserved. The maxillary is overlapped by the hind alveolar part of the premaxillary, and unites therewith by a long oblique suture (21″). The maxillary, receding, expands and sends upward a long slender pointed process to articulate

with the nasal; it then joins the malar and the prefronto-lacrymal, and descends internal to the mandible to join the palatine.[1] Each maxillary (21, 21′) affords alveoli for eight or nine teeth.

The premaxillary is the largest of the bones of the head. The pair, by confluence or connation, constitute the fore part of the upper jaw (22), expanding from a sub-obtuse apex as it recedes, and preserving its entireness for an extent of about two inches. This tract seems to be arched above transversely, with a slightly convex upper longitudinal contour continued along the medial ray or process (22′). Of the configuration of the palatal surface the specimens give no evidence. From the analogy of *Pterodactylus Cuvieri* and *Pt. Sedgwickii*,[2] we may infer that this (premaxillary) part of the bony roof of the mouth was entire, and strengthened by a median ridge. The lateral or alveolar borders formed alveoli for four teeth on each side. Thus the hind expansion of the premaxillary divides into three rays or processes. The upper medial or nasal ray is the longest: it is continued backward, continuing the initial curve of the upper contour of the face as far as the nasals, the mid suture or confluence of which bones it overlaps, and joins suturally to an extent precluding any movement of the upper jaw on that part of the head. The length of this ray is about 3½ inches. The pair of lower or alveolar rays extend back for about 1½ inches.

The malar (26) forms the lower narrower end of the oval orbit, sending up one pointed process (united with that of the maxillary?) toward the prefrontal, and a longer and stronger one to join the postfrontal. The squamosal (27) continues the zygomatic bar backward to abut against the tympanic. Its precise position and direction are left doubtful in the specimens hitherto obtained, but it is unquestionably present, and contributes to the fixation of the tympanic.

This (28) is a moderately long and strong pedicle, immovably articulated to the mastoid, paroccipital, and squamosal; thickest posteriorly, where it is strengthened by an outer marginal ridge, sending forward and inward a process which may articulate with the pterygoid (but of this I could not get clear evidence), expanding at its distal end to receive the abutment of the squamosal or lower zygoma, and to form the convex condyle for the articular element of the mandible.

The dentary parts of the mandible are confluent at the symphysis, which is as long as the undivided fore part of the premaxillary. The ramal part of the dentary is compressed, and gains a depth of about 10 lines before it bifurcates. The alveolar border of the dentary extends as far as that of the maxillary, viz. about 5 inches, beyond which the upper prong (Pl. 17, 32′) is continued above the mandibular vacuity, underlapping the surangular (29) and terminating in a point. The lower prong (ib. 32″) terminates in a point before attaining the vacuity; it is underlapped by the fore part of the angular (30), with which it articulates.

[1] This description is on a homological hypothesis, subsequently discussed (p. 486).

[2] *Pterosauria*, Pl. 7, fig. 1, *b*.

The divergence of the hinder prongs of the dentary exposes a small part of the splenial (31). The vacuity, if it be natural and not due to abrasion of a thin outer wall, is a long and narrow oval, 1 inch 8 lines in length, 6 lines in breadth. It is circumscribed behind by the confluent angular and surangular elements (29). The angular (30) forms a slight projection behind the articular concavity; it expands vertically, and contracts transversely as it advances, contributing a small share to the lower border of the vacuity, and contracting to a point below the dentary, about 5 inches from the angular process.

The range of variety shown by the skull is considerable in the order *Pterosauria.* In relative size, as in the expanse of the antorbital vacuity, *Pterodactylus crassirostris* [1] comes nearest to *Dimorphodon;* but the orbit is relatively larger, and the nostril much smaller. In *Rhamphorhynchus Gemmingi* the nostril and antorbital vacuity are of equal size, and each is about one eighth the size of the orbit, which is proportionally larger than in *Dimorphodon.* In *Pterodactylus longirostris* [2] the nostril is larger than the orbit; the antorbital vacuity is not half the size of the orbit. In *Pterodactylus suevicus* [3] the antorbital vacuity is still smaller. In *Pterodactylus Kochii* [4] that vacuity is limited, as in *Chlamydosaurus,* to the upper part of the boundary between the large orbit and the long and large nostril. In *Pterodactylus longicollum* [5] it appears to be wanting.

The shape of the skull offers many modifications in the several species, from the long and slender type of that of *Pterodactylus scolopaciceps* and *Pt. longirostris* to the shorter and deeper cone indicated by *Pt. conirostris,*[6] and to the inflated and more or less anteriorly obtuse form exhibited by *Dimorphodon* and the more gigantic *Pterodactylus simus.*[7]

The position of the tympanic pedicle varies from the almost vertical one in *Dimorphodon* to the almost horizontal one in *Pterodactylus longirostris* and *Pt. Kochii.* In *Pt. crassirostris* it shows an intermediate slope or position.

The mandible, conforming in relative depth and length to the general shape of the skull, has the symphysis longest in those species with long and slender jaws. In *Pterodactylus suevicus* the symphysis extends along the anterior third part of the mandible. In *Pt. crassirostris* it is shorter, and still shorter in *Dimorphodon.* The depth of the rami decreases behind the dentigerous part in *Pterodactylus longirostris.*

The generic dental character of *Dimorphodon* has been given in detail in the special descriptions of the specimens figured in Pls. 15 and 16. The range of variety mani-

[1] *Pterosauria,* Pl. 1, figs. 2—4.

[2] Ib., fig. 1.

[3] Quenstedt, op. cit.

[4] Von Meyer, op. cit., tab. i, fig. 2.

[5] Ib., ib., tab. vii, figs. 1—4.

[6] Dixon's 'Geology and Fossils of the Tertiary and Cretaceous Formations of Sussex, 4to, 1846, Pl. 38.

[7] *Pterosauria,* Pl. 6, figs. 1—3.

fested in this character is considerable in the present order, although in no species has any departure been observed from the predatory zoophagous condition. The teeth, always simple and pointed, vary in shape, in number, in position, in relative size. *Pterodactylus crassirostris* exemplifies the laniariform type of teeth, more or less elongate, and separated by intervals of varying extent. In this not uncommon condition the teeth are longest in the upper jaw, as offering more resistance than does the lower jaw in aid of the weapons most deeply implanted in the struggling prey.

In *Pterodactylus longirostris* the teeth are rather small, subequal, with short intervals, a little widening toward the hind end of the series, which is restricted to the anterior half of the jaw, both above and below.

In some *Pterosauria* a certain extent of the fore part of both upper and under jaws is edentulous, and from its shape has been inferred to have supported a horny sheath. The teeth are long slender canines, with wide intervals. They number from about 8 to 10 on each side of the upper jaw, and from 7 to 8 in each ramus of the mandible. Von Meyer proposed for this modification of mouth the generic name *Rhamphorhynchus*.

Dimorphodon shows the combination of scattered laniaries, with small, more closely set serial teeth in the lower jaw; it has more numerous teeth, occupying a greater extent of the alveolar margins of the jaws, than in any other Pterosaurian.

The very small teeth which have been observed in the short jaws of the little *Pterodactylus brevirostris*[1] are most probably characters of immaturity, not of species.

In regard to the bony structure of the head and the dentition, the general result of observation and comparison of Pterosaurian fossils, and common consent of competent investigators, having excluded the volant Mammals from the claim of affinity, the question becomes narrowed to whether the skull in *Pterosauria* more resembles that in the cold-blooded or the warm-blooded oviparous air-breathing Vertebrates.

Hermann von Meyer, who has contributed a great and valuable share to our knowledge of the Pterosaurian order,[2] quoting Oken's opinion, "that the skull is intermediate in character between that of the Chameleon and Crocodile," sums up his own conclusions on that head in the following terms:—"The skull of *Pterodactylus* is essentially comparable only with that of Birds and Saurians. The preponderating resemblance with the Bird's skull cannot be contested. Against this, however, is a remarkable dissimilarity in certain parts which, on the other hand, approximates it to the type of Saurians."[3]

The term *Sauria* is here used in the sense of Brongniart and Cuvier, and it is open

[1] Goldfuss, loc. cit., tab. x, fig. 2.

[2] Especially in the admirable summary of his own and others' researches, in the part of his great work, 'Zur Fauna der Vorwelt' relating to "Reptilien aus dem lithographischen Schiefer," &c., fol., 1860.

[3] "Der Schädel der Pterodactyln, der nach Oken zwischen Chamäleon und Crocodil stehen würde, lässt sich eigentlich nur mit den Vögeln und den Sauriern vergleichen; die überwiegende Aehnlichkeit mit dem Vogelkopfe kann nicht bestritten werden; ihr gegenüber steht aber eine auffallende Unähnlichkeit in gewissen Theilen, die dafür zum Zypus der Saurier hinneigen."—Op. cit., p. 15.

to the unbiassed investigator, and, indeed, becomes plainly his business, to determine, not merely whether Avian or Saurian characters predominate in the Pterosaurian skull, but to define the degree of affinity or correspondence of cranial structure therein traceable to such structures in *Enaliosauria, Dinosauria, Dicynodontia, Crocodilia, Lacertilia,* each of which may be a group, organically, of co-ordinate value with *Aves.*

Greater respect to the memory of so unbiassed a seeker after truth cannot be shown than by weighing with due care and what judgment one may be able to bring to the task the value and significance of each well-determined evidence of the cranial structure which Von Meyer has described and reasoned upon.

It is to be regretted that not in any of the numerous figures of the skull of *Pterosauria,* original or copied, has Von Meyer indicated the bones which he describes. When he writes—"The temporal bone lies external to the parietal and principal frontal bones, and mainly forms the temporal fossa,"[1] one much wishes he had indicated his 'Schläfenbein' in the skull of *Rhamphorhynchus Gemmingi,* pl. iii, fig. 4; pl. ix; pl. x, fig. 1; or in the more instructive example of cranial structure which he has borrowed from Goldfuss for the subject of his pl. v (*Pterodactylus crassirostris*).

By 'Schläfenbein' Von Meyer may mean that element of the compound 'temporal bone' of anthropotomy which I have called 'squamosal.' No doubt in Man and most Mammals the squamosal does contribute a notable share to the formation of the temporal fossa, whence the name 'temporal' given to the incongruous group of cranial elements coalescing in such warm-blooded Vertebrates with the squamosal, so exceptionally expanded in the *Mammalia.* But as to the value of the bed of the temporal muscles in determining the homology of the bones forming it, I would refer to the remarks in my work on the 'Homologies of the Vertebrate Skeleton.'[2]

Some clue to the bone signified by Von Meyer may be got from the following remarks—"Anteriorly it seems not to take, as in Birds, a share in the formation of the orbital rim; here, much more as in Saurians, it is pushed aside or supplanted by the postfrontal."[3]

The term 'temporal bone' (Schläfenbein) has been used in various senses, but whether it be applied to that element which I, with Cuvier, call 'mastoid' in *Reptilia,* or to that which others,[4] with Cuvier, call 'temporal' (meaning squamosal) in Birds, there is no bone that Von Meyer can be supposed to mean by 'Schläfenbein' which forms any part of the rim of the orbit in Birds.

Von Meyer recognises a 'postfrontal' ('Hinterstirnbein') in *Pterosauria,* and states

[1] "Das Schläfenbein liegt aussen an dem Scheitelbein und Hauptstirnbein, und bildet hauptsächlich die Schläfengrube."—Op. cit., p. 15.

[2] 8vo, 1848, p. 33.

[3] "Vorn scheint es nicht wie in den Vögeln an der Bildung des Augenhöhlenrandes Theil zu nehmen hier vielmehr wie in den Sauriern durch das Hinterstirnbein verdrängt zu werden."—Op. cit. p. 15.

[4] Hallman, "Die vergleichende Osteologie des Schläfenbeins," p. 8, pl. 1.

that it pushes away his temporal (Schläfenbein) from the orbit. In *Pterosauria* the postfrontal (Pl. 17, 12) is undoubtedly interposed between the bone I determine as 'mastoid' (ib. 8) and the orbit (ib. *o*); and my 'mastoid' in *Pterosauria* answers to Cuvier's and Hallman's 'temporal,' *i.e.* squamosal, in Birds. We may conclude, therefore, that Von Meyer's 'Schläfenbein' in *Pterosauria* is that marked 8 in the skull of *Pterodactylus crassirostris*.[1]

Certain it is that no bone answering to 8 in Pls. 15, 16, 17 of the present Work contributes to the formation of the orbit in any Bird. In the great majority of that class, as is well known, the rim of the orbit is incomplete below; it is formed above by the frontal, before by the prefrontal and lacrymal ('antorbital' of ornithotomists), behind by the postfrontal ('postorbital,' ib.). Where, as in some *Psittacidæ*,[2] the orbital rim ('Augenhöhlenrandes') is complete, the lower complement is formed by an extension of ossification from the antorbital to the postorbital processes, independently of either Cuvier's temporal (8) or my squamosal (27) in Birds.

I confess that the foregoing result of the analysis of a main ground of Von Meyer's assertion as to the "incontestable similarity between the Pterosaurian and Avian types of cranial structure" has not a little tended to shake my confidence in the grounds on which he has pronounced definite judgment on the matter. So far as we have yet got evidence of the structure of the skull in *Pterosauria*, it seems that, contrary to the rule in Birds, the orbital rim is entire; and that its lower border is completed by the zygomatic arch, and chiefly, if not exclusively, by the malar element; whereas, such arch passes freely beneath the orbital rim in the few Birds with that rim entire. Now, in this part of the cranial structure the *Pterosauria* agree with the *Crocodilia*: as in them the malar (26) sends up a process to unite with one descending from the postfrontal (12) to complete the orbital rim behind.

In the small species of Pterodactyles (*Pt. longirostris*, *Pt. scolopaciceps*, and in the perhaps immature animal represented by *Pt. brevirostris*) the hind convexity of the cranial wall is not marked by the apophysiary developments of paroccipital and mastoid, and accordingly resembles that part of the cranium in Birds, especially the smaller *Grallæ*; but before this similarity of shape can be pressed into the argument for the Avian affinity of the *Pterosauria*, it should be shown to be common to or constant in the extinct volant order.

But this is far from being the case. When a Pterosaur has gained the size of *Pterodactylus crassirostris*[3] or *Pter. suevicus*,[4] the back of the skull shows no cerebral swelling, but only the crests and processes for muscular attachments, as in other *Reptilia*

[1] *Pterosauria*, Pl. 1, figs. 3 and 4.

[2] 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, pl. i, fig. 1 (*Calyptorhynchus*); 'Anatomy of Vertebrates,' 8vo, vol. ii (1866), p. 51, fig. 30 (*Psittacus*), also p. 63.

[3] Goldfuss, op. cit., pl. vii.

[4] Quenstedt, op. cit.

of similar size. Even in *Rhamphorhynchus Gemmingi* the cranial convexity is not posterior, but is limited to the temporal fossæ behind the orbit, as in the specimen figured by Von Meyer in pl. ix, op. cit.; and this indication of the optic lobes is less conspicuous in the subject of pl. x, fig. 1. In *Dimorphodon* there is still less trace of this alleged Avian characteristic.

The bone which, in the Bird, as in the Pterosaur, forms part of the otocrane, articulates with the ex- and par-occipitals behind, with the alisphenoid in front, with the parietal above, and with the petrosal within, which contributes the articular surface to the tympanic and the upper rim to the meatus auditorius, also articulates in the Pterosaur, as in the Crocodile, with the postfrontal: and this character appears to be constant in the *Pterosauria* as in the *Crocodilia,* while it is exceptional in *Aves.* In the particulars in which the bone 8 differs in the *Pterosaurian* from that in the Bird, it agrees with 8 in *Crocodilia;* as *e.g.* in its high position in the cranium, owing to the low development of the cranial chamber; its greater degree of projection from the true cranial walls; the extensive and suturally fixed character of its articulation with the tympanic as compared with the more definite and restricted glenoidal movable articulation which the mastoid (8) affords to 28 in Birds. In all these circumstances, whether the bone 8 (Pl. 17, fig. 1) be called mastoid or squamosal, it is Reptilian, not Avian, in the Pterosaur.

Herr VON MEYER states, in another of his comparisons, that in the *Monitor, Iguana,* and *Stellio,* the prefrontal ('Vorderstirnbein') enters into the formation of the periphery of the external nostril (Nasenloch).[1] This is the case with *Varanus,*[2] not with true Monitors.[3] In *Tejus nigropunctatus* some extent of the suture between the nasal and the maxillary intervenes between the prefrontal and the nostril. The non-extension of the prefrontal to the external nostril shows no Avian affinity in *Pterosauria*; rather an agreement with the majority of *Reptilia,* as, for example, with the whole order of *Crocodilia.*

In some *Crocodilia* (*Teleosaurus*) and *Lacertilia* (*Chlamydosaurus, Lyriocephalus*) there is an antorbital vacuity, which, in the latter Lizard (Pl. 17, fig. 3, *a*), is equal in size with the nostril (ib., *n*) and intermediate in position between that cavity and the orbit (ib., *o*), which is large. A process of the maxillary rises obliquely backward to join the nasal, and to separate the intermediate vacuity from the external nostril. The lacrymal and prefrontal form the bar dividing the intermediate cavities from the orbit. In most Birds a small intermediate vacuity is partitioned off from the nostril by a process of the maxillary rising to join the nasal, and is similarly separated from the orbit by the lacrymal, which descends to join the malar. The great range of variety in the development of this

[1] 'Zur Fauna der Vorwelt,' fol., 1860, p. 16.

[2] See Cuvier, 'Ossemens fossiles,' v, pt. 2, pl. xvi, fig. 1 ('grand Monitor du Nil, *Lacerta nilotica*'), p. 259, the *Varanus Dracæna* of Merrem, *Varanus niloticus* of most modern erpetologists; also in pl. xvi, fig. 7, 'Monitor du Java,' p. 260; the *Varanus bivittatus,* of Merrem.

[3] As *e.g. Tupinambis teguixin,* 'Sauve-garde d'Amérique.' Cuvier, vol. cit., pl. xvi, figs. 10, 11, and *Thorictes Dracæna,* ib., figs. 12, 13; 'La Dragone,' ib., p. 263.

'intermediate' or 'antorbital vacuity,' in *Pterosauria*, has already been pointed out; but the comparable structure is by no means peculiar, as Von Meyer would lead one to infer, to the skulls of Birds.[1]

In no Pterosaurian has any obvious and unmistakeable suture been seen indicative of the respective shares taken by maxillary (21) and premaxillary (22) in the formation of the dentigerous part of the upper jaw: both bones combine to support the array of teeth; they have coalesced, at least at their external or faci-alveolar plates; as, likewise, have the right and left premaxillary portions forming the fore end of the upper jaw. The suture between this premaxillo-maxillary bone and the suborbital portion of the zygomatic arch remains. Accordingly, there is a choice of analogies in the interpretation of the observed facts: a proportion of the compound bone may be assigned to the premaxillary, according to the analogy of the Crocodile and Lizard; or the whole may be called premaxillary, according to the analogy of the Ichthyosaur.

Goldfuss, guided by the Lacertian analogy, limits the premaxillary to the anterior part of the upper jaw, and to the upper part of the external bony nostril (*n*); and he illustrates this view by a dotted line representing the assumed suture in his restoration of *Pterodactylus crassirostris*, in pl. ix (op. cit.).[2] Von Meyer assumes, as arbitrarily, the Ichthyosaurian analogy, but views it as a specially Avian one, and ascribes to the *Pterosauria* a bird-like premaxillary,[3] and this determination is indicated by the numerals on the restoration of the skull of *Pterodactylus compressirostris*, p. 249, Pl. 1, fig. 5.

Of the maxillary bone (my 21) Von Meyer merely remarks that "it does not follow the type of Birds" ("folgen nicht dem Typus der Vögel," ib., p. 15). And yet, if the Pterosaurian premaxillary be interpreted according to that type, forming so large a proportion of the upper jaw as to include all the teeth, the edentulous maxillary must have had a correspondingly Avian proportion and position. Only, whereas in most Birds the small and slender maxillary sends up a process helping to define the back part of the nostril and fore part of the antorbital vacuity, the corresponding process in *Pterosauria* would be (as indicated in my Pl. 16, 22^x), part of the premaxillary.

I incline to believe, however, that it may prove to belong to the maxillary; that the dentigerous part of the upper jaw is due, in *Pterosauria*, to the combined maxillaries and premaxillaries, but that the latter take a larger share in the formation of the alveolar tract than Goldfuss conjectures. One ground of such opinion is this: the portion of upper jaw with six pairs of laniary teeth in the huge *Pterodactylus Sedgwickii*, in which the palatal surface could be clearly worked out,[4] showed that the anterior expansion, with the group of three pairs of teeth, could hardly have been

[1] "Zwischen Nasenloch und Augenhöhle liegt eine dritte Oeffnung, die wiederum an den Vögelschädel erinnert."—Op. cit., p. 16.

[2] Copied in Pl. 1 (*Pterosauria*) of the present Work.

[3] "Ein Vögeln-ähnlichen Zwischenkiefers," v, p. 15, op. cit.

[4] Monograph, Suppl. No. 1 (1859), Pl. I, figs. 1, *a*, *b*.

separated by a suture, at the slight constriction suggesting that structure in *Pt. crassirostris*,[1] without leaving some indication of its original existence, especially on the palate.

In the anterior confluence of right and left premaxillaries, and the backward production from their upper part of a bony bar uniting with the nasals and dividing the nostrils, we have a character of the Dicynodonts and of some Lacertians (*Varanus*) as well as of Birds, and the Saurian affinity is shown to be the truer one by the firmness of the naso-premaxillary union and the absence of any power of, or provision for, that hinge-like movement of the upper mandible upon the cranium which is peculiar to, though not constant in, the Avian class. Moreover, the outer surface of the premaxillary shows none of that spongy porosity and rugosity which relates to the sheath or horny covering of the beak characteristic of the Bird. Such structure has not even been detected in the feeble trace of edentulous anterior production of the upper jaw in *Rhamphorhynchus*, Von Meyer. I cannot, therefore, see, with Von Meyer, the beak of the Bird in an animal with a fixed and toothed upper jaw;[2] for on every hypothesis of its bony structure it finds a closer resemblance among the toothed Reptiles than in the class of Birds.

The mandible, or lower jaw, is supported, as in all Vertebrates below Mammals, by the tympanic, viz. the bone (28, Pls. 16 and 17) which is shown by its osseous connections, its relations to the 'facial nerve,'[3] or its equivalent the 'ramus opercularis,'[4] and by its mode of formation, to answer to that which in Mammals is mainly reduced to the function of supporting the ear-drum. In air-breathing Ovipara it superadds this function to its more constant and essential use in non-mammalian Vertebrates, of supporting the lower jaw.

In reference to the question of affinity before us, the tympanic gives valuable evidence by reason of the moveable articulation and peculiar connections with the upper mandible essentially correlated to a covering of feathers. In *Pterosauria* the tympanic at its proximal end resembles that of Lizards by its fixed sutural mode of union with the cranium, and it furthermore resembles that in Crocodiles by the abutment of the zygoma against its distal end, to which it is suturally attached.

In Birds the tympanic enjoys a synovial moveable articulation by a single or double condyle at its proximal or cranial end, and presents a synovial cavity to a condyloid convexity of the hind part of the zygoma. By this test, therefore, the *Pterosauria* are shown to be not only 'Saurian,' but to be nearest akin to the existing orders which possess double-jointed ribs and the correlated cardiac structure. The difference of shape between the tympanic of the Pterodactyle and that of the Bird is too strongly marked not to have attracted attention; but I do not find in that of the Chameleon the

[1] Goldfuss, loc. cit.

[2] "Wir sehen also hier die Schnautze der Vögel auf ein Thier mit unbeweglicher und mit Zähnen bewaffneten Schnautze angewendet."—Op. cit., p. 15.

[3] 'Anatomy of Vertebrates,' vol. ii, 8vo, 1866, p. 124, vol. iii, p. 155.

[4] Ib., vol. i, p. 303.

most resemblance to the *Pterosaurian* tympanic.[1] For, besides the Lacertian freedom of the bone from zygomatic abutment, the tympanic in the Chameleon has not the longitudinal strengthening ridges, nor the process turned toward the pterygoid.

The dentigerous mandible, like the maxilla, speaks for the Reptilian affinity of *Pterosauria;* the distinct sockets for the teeth ally them to the higher forms of *Sauria*. In reference to the generic modification of dentition in *Dimorphodon*, it has been remarked that this early form of flying dragon seemed to have derived one feature or modification from the Fish, and the other from the Crocodile or Plesiosaur.[2]

The length of the neck, which is not always equal to that of the head, is due, in *Pterosauria*, rather to the length than the number of the vertebræ. Counting the axis with the small coalesced atlas[3] as one, I give seven cervical vertebræ to the *Dimorphodon macronyx* (Pl. 17, fig. 1, c). Of these a series of four are preserved in the specimen (Pl. 16, c), showing, as described, the characteristics of the Pterosaurian cervical vertebræ which had been determined and illustrated in a former Monograph.[4]

CUVIER,[5] in his searching analysis of the evidence at his command of the osseous structure of the *Pterodactylus longirostris*, concluded that the cervical vertebræ were not fewer than seven, as in *Crocodilia* and *Mammalia*, or not more than eight, as in *Chelonia*.

GOLDFUSS was able to demonstrate the vertebral formula in his famous specimen of *Pterodactylus crassirostris*.[6] The number, 'seven,' was, however, obtained by reckoning the atlas distinct from the axis, and the last cervical may have been relegated to the dorsal series.

QUENSTEDT[7] shows seven cervicals in his instructive example of *Pterodactylus suevicus*, reckoning the atlas and axis as one vertebra; and this analogy I have followed in the restoration of *Dimorphodon*.

Rhamphorhynchus Gemmingi has six cervicals, counting the coalesced atlas and axis as one; but in the specimen figured by Von Meyer in his pl. ix,[8] there seems to be the centrum of a short 'seventh' cervical between the longer 'sixth' and the first (dorsal) vertebra supporting a long free pointed rib. It is certain that the number of cervicals does not exceed the latter reckoning or fall short of the first. Thus it is plain that the *Pterosauria* exemplify the Crocodilian affinity in the cervical region of the vertebral column. Lacer-

[1] "Dieser Knochen ist nicht wie in den Vögeln quadratisch, sondern cylindrisch stielförmig beschaffem.—Hierin, so wie in einingen andern Theilen, zeigt das Thier die meiste Aehnlichkeit mit *Chamaeleon*."—Von Meyer, op. cit., p. 16.

[2] 'Report (Sections) of the British Association for the Advancement of Science,' 8vo, 1858, p. 98.

[3] *Pterosauria*, Pl. 7, figs. 11—14.

[4] Pl. 8. Pl. 12, figs. 1, 2 and 4.

[5] 'Ossemens fossiles,' tom. cit., p. 367.

[6] "Man zählt 7 Halswirbel, 15 Rippenwirbel, 2 Lenden, and 2 Kreuzbeinwirbel," loc. cit., p. 79.

[7] Op. cit., figs. 1—7.

[8] Op. cit.

tians have fewer definite cervicals; Birds have more. I have not seen any Bird with fewer than eleven cervicals.[1] The length and flexibility of the neck is correlated with the covering necessitated by the high temperature of the Bird.[2] The cold-blooded flying Reptiles have a comparatively short and rigid neck, but of a thickness and strength proportionate to the size of the head, and adequate to the work to be performed by the jaws in overcoming and bearing away the prey they may have seized.

The chief variety manifested by the *Pterosauria* in the cervical region is in the relative length of the last six vertebræ; this is greatest in *Pterodactylus longicollum* and *Pt. longirostris;* it is least in *Pt. crassirostris* and *Dimorphodon macronyx,* and apparently also in *Pterodactylus simus,* if we may judge by the breadth, compared with the length, of the vertebra figured in Pl. 12, figs. 1 and 2.

There seems to have prevailed a greater range of variety in the number of vertebræ between the cervical series and the sacrum. In *Pterodactylus longirostris,* Cuvier estimated at least twelve which supported moveable ribs,[3] and nineteen or twenty in the dorso-lumbar series. Von Meyer concluded that the number of dorsal vertebræ fell not below twelve in any species, nor exceeded fifteen or sixteen in *Pterosauria. Pterodactylus Kochii* shows fourteen dorsal vertebræ; *Pt. crassirostris* not more than twelve, reckoned by the number of pairs of free ribs, which can be satisfactorily discerned.

I have seen no specimen of *Dimorphodon* yielding definitely the number of the dorso-lumbar vertebræ, *i. e.* of the vertebræ between the cervical and sacral; it is from the best considerations I have been able to give to the analogies of these vertebral formulæ, in better preserved examples of other species of *Pterosauria*, that I assign thirteen to this series in my restoration of *Dimorphodon macronyx* (Pl. 17); and I conclude that the thirteenth was a true lumbar vertebra or without connection with a free pair of ribs. If there should prove to be error in this estimate I cannot think it will extend beyond one vertebra, or at most two, in excess of twelve dorsals.

The nine dorsal vertebræ, which have kept together, in almost a straight line, in the specimen (Pl. 16, D), testify to the strength and closeness of their reciprocal articula tions, under disturbing influences which have affected so great and general a degree of dislocation of most other parts of the skeleton.

BUCKLAND seems first to have observed the convexity of one of the terminal articular surfaces of the centrum of a dorsal vertebra, and to have deduced an affinity therefrom;

[1] The Sparrow (*Pyrgita domestica*) has twelve ('Osteol. Catal. Coll. of Surgeons,' No. 1571, vol. i, p. 297).

[2] "As the prehensile functions of the hand are transferred to the beak, so those of the arm are performed by the neck of the Bird; that portion of the spine is, therefore, composed of numerous, elongated, and freely moveable vertebræ, and is never so short or so rigid but that it can be made to apply the beak to the coccygeal oil-gland, and to every part of the body, for the purpose of oiling and cleansing the plumage." —'*Anat. of Vertebrates,*' ii, p. 39.

[3] Vol. cit., p. 368:—"Il semble qu'il en est resté au moins douze en place du coté gauche." The specimen figured by VON MEYER, op. cit. in pl. i, fig. 1, shows thirteen ribs on the left side of the trunk.

(the specimen is marked *d* in the Plate 27 of his Memoir, loc. cit.), and is described "as the body of a vertebra showing a convex articulating surface, as in the Crocodile" (p. 221). QUENSTEDT's *Pterodactylus suevicus* showed similar detached dorsals, in one of which it appeared that "the articular surfaces of the body were convex at the back end, and concave at the fore part."[1] Buckland's specimen serves to dissipate any doubt on the point so important in reference to the Crocodilian affinity. It might be assumed that the Author viewed the convexity as posterior by the expression "as in the Crocodile;" and in the last of the dorso-lumbar series, which I regard, with Buckland, as 'probably lumbar,' in the sense of not being costigerous, the position of "its concave articulating surface" is demonstrated by those of the articular processes (zygapophyses) at the same end of the vertebra, which prove them to be the anterior pair, slightly prominent, looking upward and inward. BUCKLAND notes these as "two anterior spinous processes, an obvious typographical error for 'oblique' or 'articular,' venial in one not professedly an anatomist.[2]

With regard to the Crocodilian affinity inferred from this structure, it must be remembered that the procœlian structure, though it has been observed in Crocodiles from the Greensand of New Jersey,[3] is characteristic of the Tertiary and existing species, rather than of the order at large, which had more abundant and diversified (amphicœlian and opisthocœlian) representatives in the Secondary ages of Geology. Moreover, the anterior concavity and posterior convexity of the vertebral body obtain in most recent, Tertiary, and Cretaceous *Lacertilia;* and finally, the cup- and ball-joints of the centrum appear in the dorsal vertebræ of at least one genus of Birds, though with the ball in front.[4]

In the series of nine dorsals, preserved in the subject of Pl. 16, D, the centrums slightly lose length as they recede in position from the neck; the anterior ones measure 0·009 mm. = $4\frac{1}{2}$ lines; the posterior ones measure 0·008 mm. = 4 lines; the transverse diameter of the articular ends is 0·007 mm. = 3 lines. The dorsal vertebra in Buckland's specimen presents the same dimensions. These dimensions increase as the two or three anterior dorsals approach the neck, but the greater enlargement of the last cervical is somewhat abrupt.

For the shape and proportions of the ribs (in the Restoration, Pl. 17), I have those marked *b*, *c* in the original specimen,[5] and the more numerous and better preserved ones

[1] "Die Gelenkfläche der Wirbelkörper war auf der Hinterseite convex, wie beim Crokodil, vorn dagegen concav. So scheint es wenigstens."—QUENSTEDT, Ueber *Pterodactylus suevicus* im lithographischen Schiefer Würtembergs. 4to, 1855, p. 45.

[2] Buckland, loc. cit., pl. 27. [This vertebra is shown in Pl. III, fig. 2, of the present Monograph.]

[3] "Notes on Remains of Fossil Reptiles discovered in the Greensand Formations of New Jersey," 'Quarterly Journal of the Geological Society,' vol. v, 1849, p. 388.

[4] As in *Aptenodytes;* "On the Vertebral Characters of the Order *Pterosauria*," 'Phil. Trans.,' 1849, pl. x, fig. 22, p. 163.

[5] Buckland, loc. cit., pl. 27.

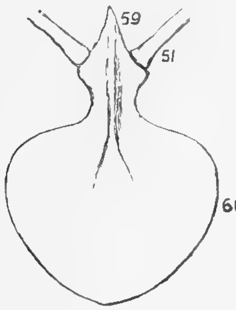
in the specimen figured in Pl. 16. Their articulations with the vertebræ have already been noticed. The ribs increase in length to the fifth or sixth, with some diminution of breadth after the third, and acquire a characteristic tenuity beyond the sixth pair. On the outer surface a groove extends from the neck, or interspace between the head and tubercle downward; the front border of the groove being somewhat prominent, but subsiding in the hinder ribs. Epipleural appendages are indicated in some specimens; but the indications are feeble, and, if rightly so interpreted, these appendages seem to have been but partially ossified.

The sternal ribs, beyond the sternum, unite below with the free ends of the abdominal V-shaped, intermuscular styles.

The irregular elongate mass (marked 18 in pl. xxviii of Buckland's Memoir) and conjectured to be "sternum—much broken, and its form indistinct" (loc. cit., p. 221) includes two crushed cervical vertebræ, and part of a third. Of the sternum I have not been able to discern a satisfactory trace in any of the specimens of *Dimorphodon;* its proportions and position are, therefore, indicated in the 'restoration' (Pl. 17) according to the analogy of that in *Pterodactylus suevicus,*[1] *Pt. simus,*[2] and in *Rhamphorhynchus.*[3]

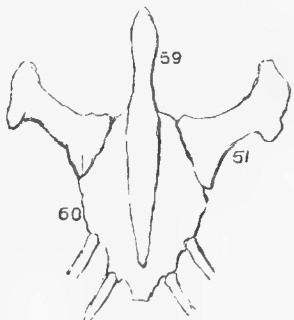
In the main, as regards breadth of the hind part and depth of the fore part, the breastbone of *Pterosauria* is formed on the Ornithic pattern; *i. e.* it is shield-shaped, and it has a keel. But the keel does not descend from the expanded portion; it is formed, as shown in '*Pterosauria,*' Pl. 12, pp. 443—448, by the vertical development of the anterior production answering to the ossified sternum of Crocodiles and to the episternum of Lizards. I would recommend a comparison of the figures of the sternum in *Iguana* and *Notornis,* given at p. 21, vol. iii, of my 'Anatomy of Vertebrates,' to whosoever may desire to form an opinion of the evidence of affinity to Birds or to Reptiles, respectively,

Fig. 1.



Pterosaur.

Fig. 2.



Crocodile.

afforded by the Pterosaurian sternum, especially as this is illustrated in figures 7 to 12 of Pl. 12, above cited. No one desirous of simply getting at the truth of the matter can

[1] Quenstedt, loc. cit. (1855).

[2] Pl. 12, figs. 7—12.

[3] Von Meyer, op. cit. (1860), pl. vii, figs. 1 and 3, and pl. ix, fig. 1.

put aside the 'post-coracoid lateral emarginations,' and other modifications defined in that Monograph as 'distinctive Pterosaurian characters.' No Bird has shown any approach to them. What modifications of the Pterosaurian sternum *Dimorphodon* may have presented, we have yet to learn.

In all cases in which it has been observed, the sternum in *Pterosauria* (fig. 1) resembles in essential characters that of *Crocodilia* (fig. 2); its chief part is a longitudinal, compressed, deep bar (59), expanding laterally, some way from the fore-end, for the articulation of the coracoids (51),[1] and having the posterior expansion (60), which remains cartilaginous in the *Crocodilia*, more or less ossified, in the form of a thin semicircular plate: but the whole bone, though adaptively modified for attachment of muscles of flight, preserves the characteristic shortness compared with the trunk, and offers a striking contrast to the long and large subabdominal plastron in most birds of flight. There is no distinct T-shaped episternum, such as exists in most *Lacertia*, and no trace of clavicles as in Lizards and Birds. Distinct lateral elements for articulation with sternal ribs I have not satisfactorily made out in any specimen.

The abdominal hæmal arches consist of slender hæmapophyses and of chevron-shaped hæmal spines.

There is evidence of one lumbar or ribless vertebra anterior to the sacrum, in *Dimorphodon;* and no Pterosaurian appears to have shown more than two such vertebræ: in this character we are again directed to the true Reptilian relation of *Pterosauria,* and warned off the beguiling marks of Avian affinity.

The indications of epipleural appendages of ribs, more or less bony, if rightly interpreted, answer to the gristly ones in *Crocodilia* and some *Lacertia.*[2] The restoration of the bony cage of the thoracic-abdominal cavity of *Dimorphodon* (Pl. 17) is based on the analogy of better preserved specimens of *Pterosauria* in regard to this part of the skeleton. Scattered elements of the hæmal arches, 'abdominal ribs,' &c., have alone been met with in the specimens of *Dimorphodon* hitherto obtained.

The sacrum, on the probable hypothesis of retention of the length of centrum shown in the lumbar vertebra, would include at least four vertebræ; if, as by the analogy of the sacrum (figured in Pl. 8, fig. 26), the vertebræ lost length at this confluent tract, there might be five or six sacrals articulating with the iliac bones in *Dimorphodon.* Von Meyer figures 5—6 anchylosed sacral vertebræ in his *Pterodactylus dubius;*[3] and the sacrum appears to consist of at least six confluent vertebræ in *Rhamphorhynchus grandipelvis,* Von Meyer.[4]

With all the evidence that the *Pterosauria,* like the *Dinosauria* and *Dicynodontia,*

[1] Pl. 12, figs. 7—12.

[2] As in *Hatteria,* see Günther's excellent Memoir, in 'Philos. Trans.,' Part II, 1867, p. 13, pl. i, figs. 17, 24.

[3] Op. cit., p. 17, pl. vi, fig. 1.

[4] Op. cit., p. 53, pl. viii, fig. 1.

exceeded the sacral formula prevailing in existing *Crocodilia* and *Lacertilia*, we should gain no firm ground therefrom for predicating Avian affinity or for building thereon a derivative hypothesis of the class of Birds. Many existing Chelonian Reptiles have a sacrum composed of more than two vertebræ.[1]

The perfect specimen of tail-vertebræ and associated bone-tendons in the specimen of *Rhamphorhynchus Meyeri* completes satisfactorily the restoration of this part of the vertebral column in *Dimorphodon*. Before the discovery of *Rhamphorhynchus*, the order *Pterosauria* was known only through species having the tail very short. Not only were the vertebræ comparatively few, estimated at twelve or thirteen in *Pterodactylus longirostris*,[2] at fourteen in *Pt. spectabilis*, at fifteen in *Pt. scolopaciceps*,[3] and as low as ten in *Pt. Meyeri*,[4] but they were very small and short. The great advocate of the Avian affinity of the Pterosaurs, Soemmerring, based his chief argument in this character. But Cuvier was able to adduce instances of *Reptilia* with tails as short; and he might now have cited a Bird with a tail-skeleton as long, as slender, and as many-jointed as in divers Saurians.[5] The earliest indication of a range of variety in this part of the bony framework of a Pterosaur was deduced, with his usual sagacity, by Buckland.

In the original specimen of *Dimorphodon* are three caudal vertebræ at the base of the tail, marked K, in pl. xxvii of his Memoir, from the size of which vertebræ, together with the larger and longer legs, as compared with *Pterodactylus longirostris*, Buckland inferred that the entire "tail was probably longer, and may have co-operated with the legs in expanding the membrane for flight."[6] "A long and powerful tail," he proceeds to remark, "is in strict conformity with the character of a Lizard" (ib.).[7]

Buckland would have had further direct confirmation of the length and strength of the tail of his Lias Pterosaur, if he had recognised the series preserved at *a, a'*, in his pl. xxvii, as caudal vertebræ; but they were conceived to belong to the neck, notwithstanding their slenderness and length, and that around them were "small cylindrical bony tendons, resembling the soft tendons that run parallel to the vertebræ in the tails of Rats."[8] When the evidences of caudal structure were first recognised by Von Meyer, in *Rhamphorhynchus Gemmingi*, he detected the homologous structures in pl. xxvii of

[1] 'Anat. of Vertebrates,' vol. i, p. 65.

[2] By Cuvier, vol. cit., p. 368.

[3] Von Meyer, op. cit., p. 17.

[4] Ib., p. 17.

[5] Owen "On the *Archæopteryx*," 'Philos. Trans.,' 1863, p. 33, pls. i—iv.

[6] Buckland, loc. cit., p. 221.

[7] *Archæopteryx* had not then been discovered; else, it might have been objected to the above hint of affinity, not only that there had been short-tailed Pterodactyles, but also long-tailed Birds.

[8] "Mr. Clift and Mr. Broderip have discovered that the remaining cervical vertebræ are surrounded with small cylindrical bony tendons of the size of a thread. These run parallel to the vertebræ, like the tendons that surround the tails of rats, and resemble the bony tendons that run along the back of the pigmy musk and of many birds" (loc. cit., p. 218).

Buckland's Memoir, and suggested that its subject might belong to the same section or genus.[1] The subsequent discovery of the skull and dentition has, however, shown that another generic section of *Pterosauria*, or at least one species thereof, had a similar long and stiff tail. The modification involving that quality does not, however, extend throughout; the anterior caudal vertebræ retain the more normal character, and the appendage would be most moveable at its base. No doubt a small degree of yielding at the many persistent vertebral joints—for complete anchylosis has not been observed—would allow a slight curvature to the extent to which the tail is represented as yielding to a lateral force in the restored figure (Pl. 17, fig. 2). The number of the caudal vertebræ in *Dimorphodon macronyx* was at least thirty; the termination of the specimen figured in Pl. 17, does not indicate a loss there of as many centrums as would bring the number up to thirty-eight, which are assigned by Von Meyer to his *Rhamphorhynchus Gemmingi.*

As we cannot, therefore, with Soemmerring, insist on the shortness of the tail in some *Pterosauria* as proof that they were Birds, so neither can we conclude from the length of the tail in other *Pterosauria* that they were Reptiles. The legitimate taxonomic deduction from such caudal modifications is, that they are not of sufficient importance for determination of a class, and that they do not exclusively characterise the genus. They indicate adaptations in an extreme and variable part or appendage of the body to special powers or ways of movement, or sustentation, in air of the present group of volant animals.

So, likewise, it cannot be, as it has been, inferred from the length of tail in *Archæopteryx*, that it was a Reptile.[2] What we learn from that Avian fossil is akin to what we have learnt from Pterosaurian remains, viz., that the tail is a seat of extreme modification, in respect of length and number of joints, within the limits of the feathered class. Mammalogists, with a like drift, could add instructive evidence of corresponding caudal variability within the limits of the order, as in the volant *Cheiroptera,* and even within the bounds of the family (*Bradypus* and *Megatherium, e.g.*).

The value of the discovery of *Archæopteryx*, in relation to *Pterosauria*, is enhanced by the peculiar nature of the matrix, conservative of cutaneous as well as of osseous characters; showing casts of down and feathers,[3] impressions of the fine foldings or wrinkles of thin expansions of naked skin, as well as delicate tendons surrounding, working, strengthening, and stiffening the caudal framework.

With these parts the fine lithographic lime-marl should have preserved the plumose appendages of the long tail of *Rhamphorhynchus,* if that flying Reptile had possessed such; and, along with caudal plumes and vertebræ, should have been preserved the bone-tendons of the tail, if *Archæopteryx* had possessed that structure.

It is probable, from the constancy with which caudal vertebræ of long-tailed

[1] In 'Leonhard und Bronn's Neues Jahrbuch für Mineralogie,' &c., Jahrgang, 1857, p. 536.

[2] *E. g.*, as the *Gryphosaurus* of Andreas Wagner.

[3] A few of the delicate, downy body-feathers of *Archæopteryx* are clearly indicated near one side of the trunk in the slab with most of the bones of the specimen of *Archæopteryx* in the British Museum.

Pterosaurs have been found associated with their tendons,[1] that detached caudal vertebræ of *Archæopteryx* might be recognised through the want of them.

We may confidently conclude that the Oolitic mud which has entombed the greatest number and variety of the flying reptiles of its period would have shown us, when petrified into lithographic slate, their feathers, if, as warm-blooded animals, they had needed such heat-conserving a covering. The plumose clothing of the long-tailed bird of the period proves its hæmatothermal character, as the want of it shows the long-tailed pterosaur to have been cold-blooded.

The tyro, fresh from the lecture-room of his physiological teacher, ambitious of soaring into higher regions of biology than were opened to him at the medical school, impressed with the relations of active locomotion to generation of animal heat, may be pardoned for inferring that the amount of work involved in sustaining a Pterodactyle in the air would make it, physiologically, highly probable that it was a hot-blooded animal. But a competent friend, finding him bent on rushing with such show of knowledge into print, would counsel him to provide himself with a thermometer adapted to the delicate testing of the internal heat of small animals. So provided, if he should chance to beat down a chafer in full flight, the experiment, made with due care and defence of the fingers guiding the instrument, would teach him how fallacious would be the inference that, because an animal can fly, it must, therefore, be hot-blooded. Unless he happen, in introducing the bulb by the widened vent into the abdomen, to plunge it into a mass of ova, he will find the heat of the beetle, notwithstanding the amount of work involved in sustaining and propelling itself in air, not to exceed by more than one degree that of the atmosphere. If he has knocked down a female cockchafer prior to oviposition, the ovarian masses may indicate half a degree, or even one degree, higher of temperature (Fahr.). With the cooling of the air in the summer night the temperature of the *Melolontha* concurrently falls. So, likewise, would that of the flying reptile, whatever " amount of oxidation and evolution of waste products in the form of carbonic acid "[2] might have attended their exercise of flight. The constant correlative structure with hot-bloodedness is a non-conducting covering of the body. We may with certainty infer that *Archæopteryx* was hot-blooded, because it had feathers, not because it could fly.

There is no ground, from observation of the Sharks and Porpoises that accompany swift-sailing vessels, maintaining themselves near the surface, exercising their several and characteristic evolutions in quest or capture of prey, for inferring that the amount or the energy of muscular action is very different in the two surface-swimmers.

Sharks have and, no doubt, work a greater proportion of muscle than Cetaceans; a less proportion of their body is excavated into visceral cavities. Yet the Shark is cold-blooded; its temperature rises and falls with that of its medium; it has no provision, by

[1] As seen in Pl. 16, at *cd*.

[2] 'Proceedings of the Zoological Society,' April, 1867, p. 417, Prof. Huxley " On the Classification of Birds."

a blanket of blubber or other superficial modification, in aid of the maintenance of a fixed and high degree of blood-heat.

There are conditions, it is true, in which a Reptile generates a higher degree of heat than is usual, but they are not those accompanying any unusual or excessive muscular work and waste; they are attended with rest, not locomotion. The incubating Boa gives to the hand that may be insinuated between the coils surrounding the eggs the sensation of a warm-blooded animal. VALENCIENNES[1] found, in the Reptile-house at the Jardin des Plantes, when its temperature, in the month of May, was 23° (Centigrade), that the heat of the *Python*, between the folds and upon the eggs, was 41·5° (ib.); so also the heat of the incubating surface of the Bird may rise to 10 degrees (Centigr.) above the ordinary temperature—higher in this passive state than it ever reaches during flight.

The organic condition which determines the hot-blooded or cold-blooded nature of a volant Vertebrate is the separation or the commingling of the arterial and venous bloods in the course of their respective circulations. From the demonstrated absence of any heat-retaining covering of the skin in *Pterosauria*—the kind and amount of negative evidence hereon being decisive—I infer that the black and red sanguineous streams were mixed by intercommunication of the aortic trunks of the right and left ventricles, as in the Crocodile.[2] The plumose integument of *Archæopteryx* bespeaks the separation, not only of the pulmonic and systemic ventricles, but of the arterial trunks thence arising; it was, consequently, hot-blooded, not because it could exert the muscular force required to sustain itself in the air. The all-important condition of the circulating system has wide correlations, not only with the extensive superficies acting upon the surrounding medium, and being reacted upon thereby, but with a rapid and uninterrupted respiration, with an advanced status of the nervous system, especially the brain, involving higher intelligence and more lively and varied instincts, especially the parental. In the organic character determining temperature, breathing, and psychical phenomena of life, Birds agree with Mammals and differ from Reptiles.

Birds agree with Implacental Mammals (*Lyencephala*) in the development, by the embryo, of a vascular allantois devoid of villi for placental connection.[3] They agree with the same Mammals and differ from Reptiles in the transversely and deeply folded cerebellum, and in the larger proportion of that and of the cerebrum to the optic lobes. Birds

[1] "Faites pendant l'incubation d'une femelle du Python à deux raies (*Python bivittatus*, Kuhl)," &c. 'Comptes rendus de l'Acad. des Sciences,' Paris, 19 Juillet, 1841. Something akin to this occurs in the development of the generative elements in plants.

[2] 'Anat. of Vertebrates,' *i*, pp. 510—512, figs. 339, 340.

[3] This character is affirmed to be "of extreme importance, and to define Birds and Reptiles, as a whole, very sharply from Mammals."—Prof. Huxley 'On the Classification of Birds,' loc. cit., p. 416. But, then, the emphatic assertion comes from a writer on Elementary Physiology, who infers the blood of the *Pterosauria* to have been hot because they were able to sustain themselves in air!

resemble Reptiles in the absence, not only of a corpus callosum, but of a fornix and hippocampal commissure. The *Lyencephala* have the hippocampal commissure, but no corpus callosum; this characterises the Placental Mammalia. Birds differ from other Oviparous Vertebrates in the chalaziferous ovum. The particulars in which Birds differ from all Mammals and agree with Reptiles are comparatively unimportant ones of the skeleton. The occipital condyles (*e.g.*) are more completely blended or unified than in Cetacea. The tympanic is interposed between the mandible and the mastoid, as in Reptiles.[1]

Two genera of Lyencephalous Mammals retain the osteological character common to Birds and Reptiles of the connection of the scapula with the sternum by the intermediation of a fully developed coracoid, and it is one of several and more important characters disproving any sharp definition of the higher warm-blooded Ovipara, at least, from the Ovo-viviparous or Implacental Mammalia.

The scapular arch retains, in *Pterosauria,* its crocodilian simplicity, modified in shape and in the angle at which the scapula meets the coracoid adaptively for the function of flight in the limb suspended thereto. There is, consequently, a close similarity to the same elements in Birds of Flight,[2] but without any trace of the superadded furculum. The articular grooves on the sternum for the coracoids communicate or run into each other at the mid line. The articulation of the corresponding end of the coracoid must be as secure, and yet with as easy a motion, due to a well-turned synovial joint (shown first in *Pterodactylus Woodwardi* and *Pt. simus*),[3] as in any Bird. The confluence of the scapula with the coracoid seems not to be constant in the order *Pterosauria;* and where it has been found, as in *Dimorphodon* and *Pterodactylus Fittoni*, traces of the original suture are present, as represented in the large Neocomian *Pterosauria* (Pl. 10).

In some specimens of *Rhamphorhynchus Gemmingi* and in *Rhamphorhynchus longicaudus* the scapula and coracoid seemed not to have coalesced.[4] The coalescence is complete and constant (so far as may be inferred from two specimens) in *Dimorphodon.*

For the analysis of the characters of the humerus in *Pterosauria,* I may refer to pp. 448—452, Pl. 13. The chief seat of variety is the " radial crest " (Pl. 16, 53, *b*, of present Monograph). In the shape and proportions of this extraordinary process *Dimorphodon* resembles *Pterodactylus* more than it does *Rhamphorhynchus.* In the proportions of the humerus to the body there is little diversity in the several species.

The antibrachium is commonly two sevenths longer than the humerus. It consists

[1] As a taxonomic character—whatever degree of value may be adjudged to it—this mode of connection of the lower jaw with the skull gains nothing by calling the tympanic 'quadrate bone,' or by affirming it to represent the '*incus*' or the '*malleus*' of Mammalia, whichever may happen to be the favourite fancy of the day.

[2] P. 395.

[3] P. 444, pl. 12, figs. 7—12.

[4] Von Meyer, op. cit., p. 18.

of two equal-sized, closely and extensively united bones, with one or two slender styliform ossicles attached lengthwise, having the base a little below the distal ends of the radius and ulna. The latter bone shows no pits for the attachment of quill-feathers, as in the hot-blooded volant *Ovipara.* A carpus with one large and one small bone in a proximal row, and with a second large and at least one smaller bone in a distal row, is another character by which the *Pterosauria* manifest their closer affinity to Reptiles than to Birds. The remains of the gigantic species from the Cambridge Greensands have yielded the characters of the two larger carpal ossicles.[1]

Variation, as usual, begins to assert its sway as the segments of the limb recede from the trunk. This is mainly shown in the relative length of the metacarpus. In *Rhamphorhynchus Gemmingi* it is to the antibrachium as 2 to 7, and to the first phalanx of the wing-finger as 1 to 5, or rather less. In *Dimorphodon* the metacarpus is to the antibrachium rather more than 2 to 6, and is little less than one half the length of the first phalanx of the wing-finger. In *Pterodactylus longirostris* the metacarpus is two thirds the length of the first phalanx. In *Pterodactylus longicollum* the metacarpus is almost four fifths the length of the first phalanx of the wing-finger. In *Pt. suevicus* the metacarpus is one eighth longer than the antibrachium.

There are diversities also in the relative length of the phalanges of the wing-finger. In *Dimorphodon* they increase in length from the first to the third. In *Rhamphorynchus Gemmingi* the first and second phalanges are of equal length, and the third is shorter. In *Pterodactylus longirostris*, *Pt. scolopaciceps*, *Pt. Kochii*, they decrease in length from the first to the third, and in a greater degree in *Pt. suevicus.*

The most marked variety, however, if the structure has been rightly determined or be not due to some accidental mutilation of the individual, is that on which Von Meyer[2] has founded his genus *Ornithopterus*, viz. a reduction in the number of phalanges of the wing-finger from four to two, and the articulation of the proximal one to two large metacarpals. The last pointed phalanx of the wing-finger in *Rhamphorhynchus* is rather longer than the penultimate one; in *Ornithopterus Lavateri* it is only one third the length of the penultimate phalanx.

The evidences of pelvic structure in other *Pterosauria*, already referred to, leaves no doubt as to that in *Dimorphodon*, as restored at *s*, 62, 63, 64, in Pl. 17. The expansion of the ischial and pubic elements and the direction of the latter are strong evidences of Reptilian affinity, and decisive differences in the comparison with Birds. Given the greatest number of vertebræ grasped by the ilia, it falls short of the least number presented in the class of Birds, as by certain *Natatores*, which concomitantly manifest a vacillating or waddling gait. Nothing in the structure, proportions, and connections of the pelvic arch squares with the notion of bipedal progression or erect sustentation of the body and wings of the *Pterosaur*. The share taken by the hind limbs

[1] P. 452, Pl. 12, fig. 6; Pl. 14, figs. 5—9.

[2] Op. cit., p. 25, pl. vi, fig. 5.

in resting or moving on dry ground was that indicated in the restoration of the skeleton in Pl. 17.

The hind limbs of *Dimorphodon* are, nevertheless, larger and stronger in proportion than in other *Pterosauria*. The femur, in most species, equals the humerus in length, and, in *Dimorphodon*, also in thickness. In *Pterodactylus longirostris* and *Pt. Kochii* the femur is the more slender bone; in *Rhamphorhynchus* it is likewise shorter than the humerus.

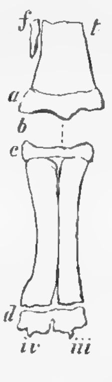
The tibia, more slender than the antibrachial bones, in *Pterodactylus longirostris* and *Pt. Kochii*, is of equal length therewith. In *Dimorphodon* the tibia is less slender in proportion to the antibrachium, and is longer by one seventh. In *Rhamphorhynchus* it is much more slender than the antibrachium, and is nearly one third shorter. The ankle-joint works between the tibia and tarsus, which, as in other Reptiles and Mammals, is distinct from the metatarsus. There is no calcaneal prominence, and the foot admits of easy rotation, as in the 'Restoration,' Pl. 17, fig. 2, where the inner toe is turned outward and the sole presented to view, to show the application of the wing-toe in flight to the interfemoral web.

Whether the trochlear terminal joint of the tibia be ossified from a separate centre in the Pterodactyle as in the Bird requires a specimen of the requisite immaturity for determining. If the hind limbs and pelvis presented the structure for sustaining and moving the animal erect on land, an epiphysial state of the articular ends of the long bones might be physiologically inferred. I conclude, from the absence of the modifications essential to bipedal station and progression in *Pterosauria*, that the articular ends of both femur and tibia, including the distal condyles of the latter bone, were co-ossified with the shaft as in other Saurians.

When in warm-blooded Vertebrates, whether Birds or Mammals, the metapodial elements of different toes coalesce, the epiphyses of such coalesced series, or 'cannon bone,' are usually connate, forming a single bone. As, *e.g.*, at the proximal end of the Cow's and Bird's metatarsus (figs. 3 and 4, *c*),[1] and also even at the distal end of the cannon-bone in Ruminants (fig. 3, *d*). I demonstrated the fact in both the metacarpus and metatarsus of a young Giraffe, in my 'Hunterian Lectures' of 1851. The specimens are Nos. 3631 and 3635 in the Osteological Collection of the Royal College of Surgeons ('Catal.' 4to, 1853, p. 601).

The distal trochlear end of the Bird's tibia, in its epiphysial state (fig, 4, *d*), answers to the distal trochlear epiphysis of the Ruminant's tibia (fig. 3, *a*). In its anchylosed state the distal bicondylar trochlear joint or end of the Bird's tibia answers to the distal bicondylar trochlear joint or end of the Pterosaur's tibia. The proximal

Fig. 3.



Ruminant.

Fig. 4.

Bird.

[1] "The upper articular surface is formed by a single broad piece. The original separation of the metatarsal bone below into three pieces is plainly indicated."—"On the Anatomy of the Southern Apteryx," 'Trans. Zool. Soc.,' ii (1838), p. 293.

epiphysis of the Bird's metatarsus (fig. 4, *c*) answers to the proximal epiphysis of the Ruminant's metatarsus (fig. 3, *c*).

The interspace between the leg and foot is the seat of variable and inconstant centres of ossification, from zero, as in *Proteus*, *Amphiuma*, *Aves*, to the four ossicles in *Crocodilus*, and the seven ossicles in *Chelone*.

The functions of the hind leg in Birds require peculiarly strong, firm, close-fitting, interlocking joints. Thus, the fibula articulates directly with the femur, and the metatarsus as directly with the tibia. No interposed ossicles are permitted to affect the simple efficiency of this tibio-metatarsal joint in the long-footed feathered bipeds. In quadrupeds and in the short- and broad-footed *Bimana* tarsal ossicles, interposed at the space *b* (fig. 3), have their use. But whether the tarsus exist or not, in the *Hæmatotherma* the articular ends of the long bones begin as 'epiphyses;' and when two or more metacarpals are to become massed into one bone, the epiphysis (*c*) is single—a very significant developmental guide to the homology in question.

The strangest aberrations in homological aims have arisen from a non-recognition of the distinction between teleological and homological centres of ossification.[1] Not only is a tibial epiphysis made into a tarsal bone—and why other epiphyses, such as the proximal one of the tibia, or the distal one of the femur, should be differently treated is not obvious—but new bones by the score are added to the cranial series. 'Basitemporals,' 'prevomers,' 'antorbitals,' 'perpendicular ethmoids,' 'ali-ethmoids,' &c. &c., have been heaped up to obstruct the comprehension of the plain and intelligible nature of the bird's skull.

The four unguiculate digits of the foot are of nearly equal length, but present a slight difference in their proportions in the *Pterosauria*. Cuvier having determined the Lacertian character of the phalangial formula of these digits, viz. 2, 3, 4, 5, adds that, apparently, the fifth digit was reduced to a slight vestige of two pieces in *Pterodactylus longirostris*.[2] Subsequently discovered species have offered a like indication, to which Von Meyer alludes as a rudiment or stump ('stummel') of the fifth toe.[3] No other specimens, to my knowledge, save the third of *Dimorphodon* (Pl. 16) and the *Rhamphorhynchus Meyeri* (p. 502), have shown the condition of the fifth digit as of three pieces, viz. a metatarsal (*m*, *v*) and two phalanges (*v*, 1 and 2).

The metatarsal of this toe shows an interesting affinity to that in the *Crocodilia* by its greater breadth and shortness in comparison to the other metatarsals. The two phalanges have proportions and forms which clearly show their adaptive relations as aids in sustaining the interfemoral or caudo-femoral parachute ('Restoration,' fig. 2, Pl. 17).

[1] Owen, "Lectures on the Comp. Anat. of Vertebrate Animals," 8vo, 1846, p. 38.

[2] "Il paroit qu'ici le cinquième étoit réduit à un leger vestige de deux pièces."—'Oss. Foss.,' vol. cit., p. 374.

[3] "Cuvier, Wagler, und Goldfuss lassen den Fuss aus fünf ausgebilteten Zehen bestehen; in allen Pterodactyln habe ich aber nie mehr als vier solcher Zehen, und höchstens noch einen Stummel vorgefunden."—Op. cit., p. 20.

The crushed condition of many of the long bones in the specimens of *Dimorphodon* shows the walls of the shaft to have been compact and thin, the cavity large. Although I have failed to detect such clear evidence of the foramen pneumaticum in these crushed bones as in some of the vertebræ, I cannot resist the inference from the structure of the long bones that they were filled with air in the living animal, as has been demonstrated in remains of the larger *Pterosauria* of the Cretaceous series.[1]

This general osteological character of the *Pterosauria* leads me to offer a few remarks on its relation to their peculiar power of locomotion among *Reptilia*, and to the affinity it may indicate to other groups of volant Vertebrates.

Weight is, of course, indispensable to directed motion through the air; but, given the weight requisite for the action against gravity resulting in flight, whatever structure tends to dispense with additional burthen enables the force to act with more avail—with less unnecessary resistance to overcome.

Where provision is made for unusual flying force, as by the enormous pectoral muscles and concomitant shape of wing in the Swift, the required weight of body called for heavier bones; hence the non-pneumaticity of the skeleton. Diminished flying force, especially with increased bulk of body, is attended with modifications of bony structure obviously adapted, and which have always been recognised in relation, to reduction of weight in the mass to be moved through the air. It is true that the mere quantity of air contained in bones would have an effect inappreciable in aid of the force raising a weight of 5 lb. or 10 lb. from the ground;[2] but the true view of the question is—given a bone of 1 foot in length and 3 inches in circumference, whether the restriction of bony matter to a thinness of $\frac{1}{2}$ a line at the circumference, and a substitution of air for the rest of the diameter throughout the shaft, be not a provision for diminution of weight and conservation of strength which does relate to facilitate locomotion through air?

If the humerus of the Ostrich (No. 1373, Osteological Collection in the Museum of the College of Surgeons, London, 'Catalogue' of do., 4to, 1853, p. 265) be compared, as to weight, with the similarly sized humerus of the Argala Crane (No. 1107, ib., 'Catal.,' p. 214), the difference is striking and suggestive; the latter bone being "remarkable for its lightness, as compared with its bulk and seeming solidity" (ib., 'Catal.,' ib.). I demonstrated the cause of the difference by a longitudinal section of the two bones. In the Bird incapable of flight the humerus is solid; in the Bird remarkable for the long-continued power of soaring in upper regions of the air, the shaft of the

[1] *Ante*, p. 451, Pl. xiii, fig. 2 *p*.

[2] A writer impugning the physiological inference of Hunter and Camper, the discoverers of the pneumaticity of the bird's skeleton, remarks:—"A living bird weighing 10 lb. weighs the same when dead, plus a very few grains; and all know what effect a few grains of heated air would have in raising a weight of 10 lbs. from the ground. The quantity of air imprisoned is, to begin with, so infinitesimally small, and the difference in weight which it experiences by increase of temperature so inappreciable, that it ought not to be taken into account by any one endeavouring to solve the difficult and important problem of flight."—Pettigrew, "On the Mechanism of Flight," 'Linnean Transactions,' vol. xxvi, p. 218, 1868.

bone is a 'thin shell of compact osseous tissue.' The relation of the weight of the volume of air occupying the capacious cavity of the Argala's wing-bone to the total weight of its body need not be taken into account in considering the problem of flight, but the relation of a hollow instead of a solid humerus is a legitimate element in the endeavour to solve that complex kind of animal locomotion. To say that a certain amount of weight in the bird is essential to the momentum of flight is no argument against the reduction to such requisite weight of the body to be upborne. Every structure so tending to lighten the body of a volant animal within the required limit is, and ought to be, recognisable as physiologically related to flight.

By the pneumaticity of the bones of the Pterodactyle, it might be inferred, from a single bone or portion of bone, to have been an animal of flight. For, although certain volant Vertebrates, *e.g.* the Bat and the Swift, may not have air-bones, no Vertebrate save a volant kind has air admitted into the limb-bones. But the effect of such admission, of such substitution of a lighter for a heavier material, is to diminish the weight without impairing the strength of the bone; the legitimate, if not sole, inference, therefore, is that it contributes to perfect the mechanism of flight.

It is a purely adaptive character, and the insignificant, barely appreciable, difference of weight due to difference of temperature in a given bulk of air makes the pneumaticity of the skeleton as available and advantageous to a cold-blooded as to a warm-blooded volant Vertebrate.

A specimen of the pterodactylian genus *Ramphorhynchus*, discovered in the lithographic plate near Eichstädt, Bavaria, with impressions of the wing-membranes, has been obtained by Professor O. C. Marsh for the Museum of Yale College, New Haven, United States.

Of this rare specimen the accomplished Palæontologist, by whom important additions to Pterosaurian organisation had been previously made, has recorded a description in the 'American Journal of Science,' vol. xxiii, with the subjoined figure of a restoration, in which the condition of the specimen leads to a conclusion that the volant membrane, after being continued from the hind-limbs upon the tail, is interrupted, and reappears as a special terminal caudal expansion, or 'rudder,' as in the subjoined cut, on which is founded the specific name:—

Ramphorhynchus phyllurus, Marsh.

IGUANODON.

SUPPLEMENT (No. III).

Bones of the Forearm and Paw ('Dinosauria,' Plates 46, 47, 48.)

THE additional elements towards a reconstruction of the Iguanodon, which form the subject of the present supplementary monograph, have been contributed by SAMUEL HUSBANDS BECKLES, Esq., F.R.S., F.G.S., and their acquisition is due to his persevering labour, liberal indifference to expense, and intelligence directing the quest, resulting in the successful exhumation of the parts in question. They were associated with the greater part of the skeleton, of which, besides the subjects of the present Monograph, Mr. Beckles secured a dentary element of the mandible, fifty vertebræ, a sternum, scapula, and coracoid, one humerus and fragments of the other, one femur, one tibia and parts of the other, a tarsal bone, the three metatarsals, and phalanges of one hind foot, and some bones of the other hind foot.

Mr. Beckles was led to this excavation by a slight indication of bone in a Wealden clay (Hastings Series), about two miles to the west of St. Leonard's-on-Sea, Sussex. The area worked up was 200 feet square, or 10 feet by 20 feet, and 4 feet deep. The bed was below high water, and could only be wrought at during one tide in the day. Nevertheless the work of exposure was conducted with such energy that it was completed in a week. "The bones were imperfectly mineralized, and could only be secured by plaster of Paris, of which I used about thirty bags, each bag containing seven pounds. As a rule I applied the plaster with my own hands; but as the weather was severe, the wind being high and cold, with occasional sleet and snow, I was compelled to leave the manipulation of more than one bone to my navvies, and consequently one femur was destroyed, one jaw, one humerus, and one tibia, nearly destroyed. Had I not made a digging expressly for these bones, the interesting specimens you have in hand could never have been obtained." [1]

[1] Extract from a letter by Mr. Beckles to the author, of the 25th September, 1871.

The half or ramus of the lower jaw preserved is represented by the dentary element, containing many of the characteristic teeth of the great herbivorous reptile, and repeating the peculiar form of the fore part of the mandible which has been recognized in previously described and figured specimens of that bone.[1] Though dislocated, displaced, and somewhat scattered in the matrix, they impressed the discoverer with the conviction or certainty of their being parts of the skeleton of the same individual. A comparison of all the bones and fragments of bone submitted to me for determination give no indication of their having belonged to more than one animal, and all are referable to an individual of the same age and size.

The left radius and ulna are in the best state of preservation; the right radius and ulna are less entire; an os cuneiforme is recognizable in the carpal series, and there are metacarpals and a few phalanges of both right and left paws.

The radius is chiefly remarkable for its powerful spinous or spur-like appendage.

The antibrachial bones in the present collection confirm the ascription to 'radius' and 'ulna' of the two bones imbedded near the upper corner, opposite the right hand, of the great slab of the 'Maidstone Iguanodon;'[2] but Mr. Beckles' specimens having been worked out of the less intractable matrix—the Wealden clay—show the configuration and characters of the surface of the entire bone.

In the following description the surface or aspect of the bone corresponding with the olecranon and 'back' of the hand is termed 'anconal;' the opposite surface, or that answering to the 'palm' of the hand, is termed 'thenal;' the surface toward that side of the forearm where lies the radius is termed 'radial;' towards the opposite side 'ulnar.' 'Proximal' and 'distal' imply the ends of the bone respectively next to or furthest from the trunk of the animal.

Ulna. Plate 46, 55.

The ulna is 1 foot 5½ inches in length;[3] 4 inches 8 lines across the radio-humeral articulation (at *a*, *b*, fig. 1); 3 inches 8 lines across the distal end; 2 inches 10 lines being the greatest diameter of the middle of the shaft.

The olecranon (*c*, fig. 1) extends 1 inch 9 lines above the humeral articular cavity (*d*, *d'*); it is obtuse, about 2 inches thick at the base, thence gradually contracting, to be continued into the ridge (*a*, fig. 1) extending along or forming the ulnar border of the

[1] More especially in the portion of the mandible of a young Iguanodon ('*Dinosauria*,' Pl. 16).

[2] '*Dinosauria*,' Pls. 1 and 2. "The radius and ulna lie with their proximal ends next the right hand upper corner, the latter being distinguished by its prominent olecranon, which is rounded as in the Great Monitor," p. 266.

[3] The length of the ulna in the Maidstone Iguanodon is estimated at 1 foot 6 inches, p. 268.

bone, to beyond the middle of the shaft, which then becomes rounded, and finally broadens to near the distal expansion of the bone (*k*, *k'*, fig. 1).

The humeral articular surface (figs. 1 and 2, *d*, *d'*) is oblong, and extends from above obliquely downward and forward to the strong anterior ridge (*e*), which, adding to its width, is then continued down to form (at *e'*) part of the cavity for the radius. The humeral surface is concave lengthwise, and also, in less degree, transversely; but both ulnar and radial borders become convex in that direction, or are rounded off and thick. The sharpest or best defined border is that which divides the lower part of the humeral articular cavity (fig. 2, *d'*, *f*, 'greater sigmoid' of Anthropotomy) from that (*g*) presented to the radius ('lesser sigmoid cavity,' ib.).

The length of the humeral cavity is $4\frac{1}{2}$ inches; the breadth across the middle $2\frac{1}{2}$ inches: the surface (*d'*, *f*, *g*, fig. 2) for the head of the radius appears to be directly continued over the well-defined lower part of the border (*d*,*f*) of the preceding cavity, directly downward, or with its plane in the longitudinal axis of the bone. This 'lesser sigmoid cavity' is semi-elliptical in shape, about 2 inches 8 lines in longest diameter, 1 inch 3 lines in the opposite direction; the upper border is straight, the lower one curved. The exact extent in the direction transversely to the head of the ulna, or in the long axis of the semi-ellipse, has suffered by fracture of the antero-inferior end or angle of the combined humero-articular cavities.

About half an inch below the radial surface the ridge (*e'*, fig. 1), continued downward from the above broken angle, expands to a rough tuberosity, which was joined by syndesmosis to a similar rough tuberosity (*r*, fig. 3) at the lower part of the anterior articular ridge of the radius.

At the proximal end of the ulna a thick, rough, long tuberosity, or tuberous ridge (fig. 2, *h*, *h*), from the radial side of the humero-radial articulation, is most prominent where it bounds or defines the radial division of that joint; below which it contracts and slightly bends to its termination (*h'*). This projection augments the breadth of the back part of the ulna below the base of the olecranon. At this part the ulna is almost flat, and the surface is roughened by thick irregular ridges, which mostly affect a longitudinal direction.

The general form of the bone at its upper three fourths is three-sided. The hinder side, continued from the above flat, rough expanse, maintains its character of flatness, gradually contracting to its termination $4\frac{1}{2}$ inches above the distal end, where the shaft begins to be rounded.

The ulnar surface of the olecranon is moderately convex, lengthwise and across, for $3\frac{1}{2}$ inches, or to below the middle of the humeral cavity. Then the surface begins rapidly to expand, by the development of the ulnar boundary (*c*) of the articulation for the radius, gaining a breadth of $4\frac{1}{2}$ inches. The ulnar surface is here (fig. 1, *i*) moderately concave, both lengthwise and across; half way down the bone the concavity is changed to a surface flattened lengthwise, and moderately convex transversely.

The third or radial side of the shaft of the ulna has been somewhat crushed in, but seems to have been rather convex transversely, and is less sharply defined than are the other two surfaces. The thick rounded border between it and the hinder surface gradually subsides at the lower fourth of the shaft, and both blend into the somewhat flattened rough surface opposite the articular one at the distal expansion of the bone.

The thick rounded border between the ulnar and radial sides of the shaft contracts about the lower fifth of the bone, inclines forward, and extends into the beginning of the rugous margin (*k*, *k′*, fig. 1), which defines, by a convex curve, the lower or distal end of the bone.

The non-articular surface of this expansion is smooth anteriorly, where the radial facet of the shaft terminates; but is roughened by oblong tuberosities posteriorly, where the hinder facet of the shaft is lost upon it.

The articular surface for the distal expansion of the radius is of a crescentic shape, with the anterior horn the longest. It is rough and irregular on the surface, indicative of the ligamentous nature of the union. The smooth ulnar surface of the shaft terminates in the hollow of the crescent. The anterior horn extends 4 inches 3 lines above the distal end of the bone; the posterior horn 2 inches 6 lines above the same end. The general breadth of the syndesmotic surface is about 2 inches, contracting at each end of the crescent.

The compact bony wall of the ulnar shaft is from 6 to 9 lines in thickness; the fine cancellous centre, of an oval form in transverse section (fig. 4), is 1 inch 3 lines by 10 lines in its diameters.

In general shape, in the better definition of the joints for the humerus and radius, and in the development of the olecranon, the ulna of the Iguanodon resembles that of the larger living *Lacertia* more than that of the *Crocodilia*. From the ulna of the Iguana and of the large Nilotic Monitor it differs in the greater relative strength and more trihedral figure, the shaft of the ulna being compressed and two-sided in the smaller recent Lizards. There is the same concavity at the proximal part of the ulnar surface of the bone; but it seems relatively deeper in the Monitor. The chief difference in the Iguanodon is the thick tuberous extension on the radial side of the radial articulation, from which is continued that border which divides and defines the posterior and radial surfaces of the shaft.

Radius. Plate 46, 54.

The length of this bone is 16 inches;[1] the greatest diameter of the proximal end (fig. 3) is 4 inches; of the distal end, from the upper border of the spur-surface (fig. 1, *m*)

[1] This appears to be its length in the Maidstone Iguanodon, but one end is covered by a crushed vertebra.

to the ulnar end of the distal articulation (ib. *n*) is 7 inches, 6 lines; from the lower border of the spur-joint (*o*) to the same part (*n*) is $5\frac{1}{2}$ inches.

The proximal surface or 'head' (fig. 1, *p*), for articulation with the humerus, is semi-elliptical. The long diameter gives the breadth above quoted; the short diameter, at the middle of the ellipse, is 2 inches 4 lines; the truncate border or chord of the semi-ellipse is toward the ulna. From the posterior two thirds of this border the articular surface for the ulna (fig. 3, *q*) extends down, $1\frac{1}{4}$ inch, at right angles with the proximal surface. It is flat and rough, semi-elliptic in shape.

The proximal surface is almost flat, feebly undulate, with a linear roughness for ligamentous union with the humerus; it is continued at its fore part upon the ridge-like prominence of the bone (fig. 3, *r*, *r'*), which bends toward the ulna as it descends, terminating $2\frac{1}{4}$ inches below the humeral surface; this rough extension of the articular surface is separated from the flatter ulnar surface by a deep, smooth pit (ib. *s*), big enough to receive the end of the thumb. Beneath this articular surface the radius contracts to a breadth of 2 inches 5 lines, and a thickness of 1 inch 3 lines; and this subcompressed form, flat or subconcave toward the ulna, convex on the opposite side, but irregularly so on both sides, continues two thirds down the length of the shaft; which, then, gains in thickness and breadth, but especially and rapidly in the latter dimension by the extension of the distal end beneath that of the ulna.

The distal surface for articulation with the ulna commences about 9 inches from the proximal end of the radius in a pointed form (fig. 1, *t*), which rapidly expands to a breadth of $2\frac{1}{4}$ inches. This part of the distal ulnar surface is parallel, lengthwise, with the non-articular surface of the shaft of the radius, is almost flat or slightly convex and rough, and might be regarded as representing a partial interosseous syndesmosis; it is continued, however, at its lower broadest part into a smoother concavity upon the proximal side (ib. *u*, *v*) of the distal extension of the radius, and this concavity receives part of the distal convexity of the ulna (ib. *k*, *k'*). The distal end of the radius is excavated by two concavities for the carpal bones; that (ib. *w*) for the hemispherical part of the scaphoid is the deepest, and measures about an inch and a half in both transverse and fore and aft diameters; the shallower concavity (ib. *x*) for the convex part of the cuneiforme is continued into a slightly convex surface, extending to the apex of the distal extension ulnad (*n*) of the radius.

On the shaft of the radius may be noticed a rough, slightly prominent tuberosity (*y*), about 15 lines by 12, at the hinder or anconal margin, commencing about 4 inches from the proximal end. The shaft is not quite straight; the anconal surface below the tuberosity gains in thickness, and is slightly concave lengthwise; the thenal surface is thinner, and slightly convex lengthwise.

The exceptional feature of this radius is an oblong, irregularly flattened, rough surface, as if caused by fracture, occupying the radial aspect of the distal expansion (*m*, *o*); consequently, opposite the surface above described for articulation with the ulna. To

this surface was joined, if not anchylosed, the base of a bone, corresponding with that which has been figured as the "horn" of the Iguanodon (*z*)[1]; the surface on the radius, like the co-adapted one on the base of the 'horn,' is 4 inches in long diameter, and 2 inches 4 lines in short diameter.

The unsymmetrical character of this supposed 'horn' led me to infer that it was one of a pair of bones, which I conjectured to be 'phalangeal.'[2] The rough flattened base of the original specimen, on part of which the cellular osseous texture was exposed, I believed to be due to the articular surface "having been chiselled or scraped away."[3] I now know that it was a natural surface due to separation from a close syndesmotic and partially anchylosed union with the distal end of the radius, as in the left antibrachial bones figured in Pl. 46, fig. 1.

In the right radius of the Iguanodon, which has afforded the subject of the present Monograph, this horn-like appendage is anchylosed, and stands out from the radial side of the distal end like a process of the bone (Pl. 47, fig. 1).

The length of the detached radial spine in the left fore-limb is 6 inches; the apex is not quite entire; the thenal surface (Pl. 46, fig. 1, *z*) is less convex across and more convex lengthwise than the anconal surface (Pl. 47, fig. 1, *z*). This surface is strongly convex transversely, slightly concave lengthwise, and is smooth along its distal half; it is roughened by thick and strong longitudinal ridges at its proximal third, and these are less developed at the corresponding part of the thenal surface.

The vascular channels indicate, as in a claw-phalanx, the system of supply of horny matter sheathing the bone.

The formidable spine, supported by this bony core, projected inward or from the radial side of the radius, with its distal border at right angles with the long axis of the bone, the proximal border (*z*) passing more obliquely to the apex of the spine-core.

The right ulna shows an exostosis at the back part of the shaft, near the base of the olecranon. Such instances of disease in Mesozoic reptiles are rare.

There is a slight difference in the shape of the proximal end of the right radius, which, nevertheless, belonged to the same individual Iguanodon, as the left one above described: the humeral surface, or 'head,' is 3 inches 5 lines by 2 inches 9 lines; the principal ulnar surface is 2 inches 3 lines by 1 inch 6 lines. The narrower surface for the ulna, extending upon the ridge-like process, with the digital depression dividing it from the broader ulnar surface, show the same characters, as at *r*, *s*, figure 3, Pl. 46.

Fracture of the shaft of the right radius (fig. 5) shows a compact bony wall, 6 to 7 lines in thickness, surrounding a finely cancellous central tract: the shaft is sub-trihedral, approaching the cylindrical form prior to the distal expansion.

[1] MANTELL, 'Illustrations of the Geology of Sussex,' 4to, 1827, p. 78, pl. xx, fig. 8.

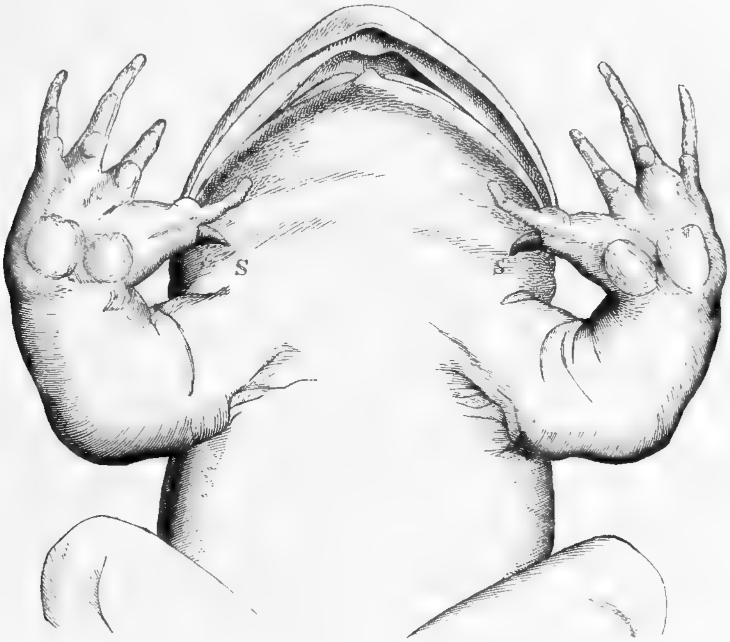
[2] *Ante*, p. 320.

[3] Ib., ib.

The radius of the Iguanodon resembles that of Lizards—*Iguana tuberculata, Monitor niloticus,* for example—in the larger and more definite extent of the proximal surface for the ulna, than exists in the *Crocodilia.* But no living reptile—crocodilian, chelonian, or lacertian—is armed like the extinct herbivorous Dinosaur.

Of other examples in the animal kingdom of limbs with spinous weapons, the first that suggested itself was the monotrematous reptile-like Mammals. But in both *Orni-*

Fig. 1.



Sexual spines of fore-limbs; or 'Hand-spurs' (s, s), Male of large S. Amer. Toad (*Cystignathus fuscus*).

thorhynchus and *Echidna* they are limited to the hind limbs, and are attached to the tarsus, not to the tibia.

In the class of Birds are a few 'spur-winged' species—*Anser gambensis, Parra jacana, Palamedea cornuta, Hoplopterus, e.g.*—in which the weapons are attached to the radial side of the fore-limbs; not, however, to the radius itself, but to the base of the metacarpus.

My friend and colleague, Dr. Günther, has kindly supplied me with the following example of spines or spur-like weapons in an existing cold-blooded air-breather; but it is a member of the Batrachian order. In *Cystignathus fuscus* a sharp, conical, horny spine, figure 1, *s, s,* is supported by a bony core attached to the radial side of the metacarpal of the innermost or radial digit.

Many species of Fish support and wield with effect formidable spinous weapons, forming part of the pectoral fins, the homologues of the fore-limbs in Iguanodon and other terrestrial Vertebrates.

The monotrematous and batrachian instances show the spinous limb-weapons to be related to sex, and to be present, or fully developed, only in the males.

In the class of Birds the carpal spurs are common to both sexes, but smaller in the female.[1]

The question remains—were the radial spines of Iguanodon common to both sexes, or developed only in one, most probably the male?

In the Maidstone specimen such appendage, with a concomitant considerable distal expansion of the radius, cannot be discerned. In the best preserved ends of the anti-brachial bones, those, viz., furthest from the humerus (as the separated fragments of the matrix, have been restored in the Maidstone specimen), the closest resemblance traceable to the more complete bones before me is at the proximal ends; and especially, as originally determined by me, in the ulna, or lower placed bone. In this view the distal ends, especially of the radius, are partly concealed by an overlying vertebra, yet not to the extent to obscure the beginning of the radial expansion if it had existed. The shafts of both radius and ulna seem to be more slender than in Mr. Beckles' Wealden specimen. It may be that this is of a male Iguanodon and the Maidstone specimen of a female one.

A strange instrument truly in aid of the amorous embrace; yet, as in the instance of *Cystignathus*, and perhaps also the *Ornithorhynchus* and *Echidna*, not without a parallel!

If the radial spines, on the other hand, were developed in both sexes of the Iguanodon, and wielded for purposes of defence by the otherwise weaponless herbivore, one cannot fail to discern in them a formidable means of transfixing an enemy—the carnivorous Megalosaur, *e. g.*—in a close death-struggle.

MANUS. Plate 48.

With the right and left anti-brachial bones and spinous appendages several bones of both the fore feet were exhumed, but not enough for a complete restoration of either foot.

They give evidence that the fore-paw was pentadactyle, and that the terminal phalanges, at least of some of the toes, were short, obtuse, rough, serving for the support of horny matter in the shape of a hoof rather than of a claw. Such evidences of the carpal bones as were collected are more or less fragmentary; and, where a satisfactory union of those belonging to one and the same bone could be made, the homology of but one bone can be safely or with probability be suggested, that, viz., which answers to the large os cuneiforme in the carpus of Lizards.

The proximal surface of this bone is divided into a convex and concave surface; the former was apparently adapted to the concavity of the ulnar extension of the distal part of

[1] The Secretary of the Zoological Society, P. L. SCLATER, Esq., F.R.S., kindly informs me that this is the case in the pair (male and female) of the spur-winged geese (*Plectropterus*) now living in the Society's Gardens.

the radius; the concavity was adapted to part of the distal end of the ulna, but leaving the ulnar end of the distal convexity of that bone (Pl. 46, fig. 1, *k*) for probable adaptation to an os pisiforme. The distal surface of the unciforme shows the concavity for an os magnum, and a well-defined flatter surface for a small unciforme.

The metacarpal of the pollex (Pl. 48, I, *m*) is 4 inches in length; 2 inches 5 lines across the broadest part of the proximal end; 2 inches across the corresponding part of the distal articulation. Both these dimensions are in the direction of the transverse breadth of the paw, the bone being subdepressed. The proximal articulation is a shallow, circular cavity continued radially upon a rough, angular production of that end of the bone. The opposite side of the articulation is produced into a broader roughened surface for syndesmotic union with the base of the next metacarpal.

The anconal surface of the bone (shown in Pl. III), for an inch or more in advance of the distal end, is roughened by longitudinal grooves and ridges: the surface then continues smoothly to the distal convexity; but shows, on each side near that surface, evidence of the powerful lateral ligaments connecting this metacarpal with the first phalanx.

On the radial side is a rough oval pit, an inch in long diameter, with the proximal border prominent and forming an angle in the radial outline of the bone. There is a similar projection on the ulnar side, but it forms the proximal end of a triangular tuberosity.

The thenal surface of the bone is more or less rough, and is divided by a low medial prominence into two facets.

The distal articulation is of an oval shape, convex in a greater degree than the proximal articulation is concave; it is 2 inches across transversely, $1\frac{1}{2}$ inch in the opposite direction, or from the anconal to the thenal surface. The plane of both proximal and distal articular surfaces is not quite transverse to the axis of the bone, but rather oblique from the ulnar forward to the radial end. The least transverse diameter, at the middle of the shaft of this metacarpal, is 1 inch 8 lines.

The metacarpal of the pollex of both right and left fore-feet has been obtained.

The first phalanx of the pollex (Pl. 46, 1) is broader and more depressed, in proportion to its length than is the metacarpal which supports it. Its proximal concavity is smaller and more shallow than the convexity to which it is adapted, though this appearance may be in some degree due to the abrasion of the margins. That part which is preserved equally bespeaks the strength of the ligamentous attachment with the metacarpal; it is most produced on the radial side of the bone (*a*), as if ossification had extended there along the lateral ligament toward the metacarpal. The opposite or ulnar roughened surface is broader, more tuberous, but less produced.

The anconal surface of the bone is less regularly convex transversely than in the metacarpal; the mid part being raised so as to divide it from the surface on each side, which is flatter transversely and slightly concave lengthwise.

The smooth surface on the radial side is continued along a notch at the radial border

of the phalanx, upon the palmar surface of the shaft, two thirds across. All the rest of that surface is grooved and roughened for ligamentous attachment.

The distal end of this phalanx is 2 inches in breadth; of this, a feebly convex, semi-oval articular surface occupies a transverse extent of 1 inch 5 lines; the breadth from the anconal to the thenal border of this surface gives that of the distal end of the phalanx, viz. 1 inch.

The series of bones does not include any phalanx adapted to or agreeing in size with this surface. By the analogy of *Sauria* and *Crocodilia*, I conclude the missing phalanx would be the terminal one. Of the proximal phalanx of the 'pollex,' Mr. Beckles' series includes both right and left.

The second metacarpal (Pl. 48, 2, *m*), or that of the index digit, is 6 inches in length. The proximal end is subquadrate, 2 inches in breadth, deviating from flatness by a slight convexity, most marked towards the ulnar side, where it probably projected into the cleft between the trapezoides and os magnum.

There is no indication of a smooth synovial surface; the union throughout, or nearly so, seems to have been ligamentous; the longest diameter in the ancono-thenal direction is toward the ulnar side of the surface, and is 1 inch 8 lines.

Near the radial side of the base is a rough surface of limited extent, apparently for ligamentous connection with the adapted surface of the first metacarpal.

On the ulnar side of the second metacarpal a rough flattened tract projects, like an exostosis, from the whole length of that side of the bone. Its ancono-thenal breadth at the base of the metacarpal is 1 inch 6 lines; it decreases to a breadth of 6 lines where it passes into the rough surface for the lateral ligament on the ulnar side of the distal end.

The anconal surface of the shaft is smooth, becoming roughened by linear striæ as it bends upon the radial surface. The thenal surface of the shaft is ridged and grooved throughout; it is nearly flat transversely, moderately concave lengthwise. The distal articular surface is moderately convex, 1 inch 4 lines in diameter; there is a protuberance on each side of the thenal part of the distal end; the ulnar side of the bone is slightly convex; the radial one in a greater degree concave; thus, the second metacarpal is slightly bent toward the radial side of the paw.

The bone described belongs to the left foot. The proximal part of the same phalanx of the right foot is preserved.

The proximal phalanx of the second toe (ib., II, 1) is 2 inches 6 lines in length; 2 inches in breadth at the proximal end; 1 inch 9 lines at the distal end. The proximal articular surface has the smooth synovial character but slightly indicated. It is subcircular in form, about an inch in diameter, with a very feeble concavity; the rough peripheral tract on nearly the same plane, from 4 to 6 lines in breadth, indicates how large a proportion of the joint had been syndesmotic: the protuberance for the lateral ligament on the radial side projects beyond the plane of the articulation; that on the ulnar side has a more distal relation to the joint. The anconal and lateral surfaces of the shaft form a continuous

convexity transversely. The thenal surface is flattened, but irregular; an oblique groove extends from the radial end of the proximal surface for about an inch onward toward the ulnar side; this groove, 4 lines in breadth, seems to be natural; the clay matrix could easily be picked out of it. Beyond the groove the short thenal surface is moderately smooth and slightly concave; a pair of hemispherical tuberosities project near the distal articulation, and are continued into the tuberosities on each side of that surface. The form of the surface is trochlear, that is, concave transversely, convex ancono-thenally; feebly defined in both directions. The breadth is 1 inch 3 lines; in the opposite diameter 10 lines. The well-defined anconal border projects a little above the level of the corresponding surface of the shaft; the breadth of the shaft at its middle is 1 inch 3 lines.

To the well-defined smooth trochlear surface of the above phalanx is adapted a surface of corresponding size, shape, and smoothness at the proximal end of a phalanx, 1 inch 3 lines in length, 1 inch $4\frac{1}{2}$ lines across that end (Pl. 48, II, 2). The breadth of the distal articulation of this phalanx is 1 inch 2 lines; its ancono-thenal diameter is 6 lines, that of the proximal surface being 9 lines. Thus, the shape of this phalanx is subquadrate and subsphenoid; the apex of the wedge being cut off, so to speak, to form the distal joint. The upper surface of the short shaft is smooth, convex transversely, concave lengthwise. The under surface is flat, rough, and irregular, and is continued into rough prominences on each side of the shaft.

To the distal articular surface of the above phalanx is adapted the proximal one of the present (ib., II, 3, 3 *a*, 3 *b*), which is terminal, ending in a rough, obtuse, thickened border (3 *b*); the breadth exceeds the length in a greater degree in this than in the preceding phalanx; it equals 1 inch 3 lines, the length of the bone being 10 lines. The greatest ancono-thenal diameter of the proximal end is 9 lines, while that of the articular surface is but 6 lines; there is no trace of attachment for the claw. The non-articular surface of this obtusely wedge-shaped phalanx indicates by its roughness that it was imbedded in a callous sheath of the integument.

Thus we have evidence that the second digit of the fore-foot of the Iguanodon had three phalanges supported by a metacarpal; that it much exceeded in length the pollex or first digit, and that it was of less breadth, though with greater ancono-thenal thickness of the proximal phalanx.

The entire length of the four bones of the second digit is 10 inches 6 lines.

The metacarpal of the third or 'medius' (ib., III, *m*) digit is 6 inches 9 lines in length; the ancono-thenal exceeds the transverse diameter, except at the distal articulation, where the two are equal; the bone is most compressed laterally at the proximal end, which is strongly convex for being wedged or received into a groove-like cavity of the os magnum. The ancono-thenal diameter at this end of the bone is 2 inches; the transverse diameter at the anconal part is 1 inch 3 lines, but narrowing towards the thenal end. The radial side of the bone has a roughened tract, narrowing forward, and of the same extent as that on the contiguous surface of the second metacarpal; but it deviates from flatness at

the parts, and in the degree in which that surface is convex in the attached bone. The two metacarpals were thus closely and ligamentously united, in a way and to an extent in which I have not observed the homologous bones in any recent Crocodilian or Lacertian. The anconal margin of the rough tract projects, ridge-like, along the proximal half of the bone. The anconal surface of the shaft begins, at an inch and a quarter from the proximal end, to be smooth, and is convex in both directions, but least so longitudinally. The ulnar surface of the shaft is roughened, but in a less degree than the radial one; the distal articular surface, single at its anconal half, where it is feebly concave, feebly concave transversely at its mid part, and much more convex in the opposite direction, has that curvature continued upon two lateral portions toward the thenal aspect of the bone, divided by an intervening channel.

The distal articular surface also inclines slightly to the radial side, where it projects beyond that surface of the shaft; it does not extend beyond the ulnar surface. It thus repeats the tendency to the bend radiad noticed in the second metacarpal, but here limited to the distal end.

The fourth metacarpal (Pl. 48, IV, *m*) is 5 inches 6 lines in length; it is more compressed than the third, especially at the anconal part; the ulnar surface sloping anconad to meet the radial one, leaving the upper surface to be represented as a rounded border; thus, the shaft is trihedral, not quadrilateral. The proximal articular surface is 2 inches ancono-thenally by 1 inch 5 lines transversely. The chief part of the articular surface traverses that end of the bone in its long axis, with a strong convexity transversely, which passes into a flatter facet at the ulnar side; this ridge-like disposition of the chief articular prominence was probably wedged between the os magnum and unciforme. The ulnar flatter surface would articulate with the latter bone; in advance of this is a rougher tract, of small extent, for ligamentous articulation with a fifth metacarpal. The radial side of the fourth metacarpal is flattened and rough for junction ligamentously at its proximal part with the contiguous metacarpal; with an interval in the rest of the extent left by the concave curve, which this surface describes lengthwise, and which interval was probably filled up by looser ligamentous tissue.

The distal articulation, 1 inch 6 lines across, and the same in the opposite direction at the radial side, resembles in character that of the third metacarpal, but with an opposite obliquity tending to direct the toe which it supported more ulnad.

The corresponding metacarpal is preserved of the right fore-foot.

To either the third or the fourth digit belongs a proximal phalanx, 2 inches 6 lines in length, 1 inch 8 lines in transverse breadth of the proximal end, 1 inch 6 lines in the same breadth of the distal end, which supports a well-defined, smooth, shallow trochlear surface, 1 inch 1 line transversely by 10 lines ancono-thenally; it closely resembles the proximal phalanx of the second digit, but is rather narrower in proportion to its length, and shows greater disparity of size between the two distal tuberosities on the thenal surface. It may belong to the right paw.

A distal phalanx (ib., IV, 4), of the same character as that of the second toe, is longer in proportion to its breadth, and deeper ancono-thenally. The rough, obtuse termination is bounded below by a transverse groove indicative of an ungual callosity of a more definite form.

The fifth metacarpal of the right fore-foot (Pl. 48, v, *m*, reversed) has been preserved. Its proximal surface is rather lozenge-shaped; the transverse diameter is 2 inches 3 lines; a circular, slightly concave, roughish articular surface is defined at the middle of the lozenge; the rougher tuberosities, extending beyond it on each side, form the truncate angles of the lozenge in that direction; a smaller extent of rough surface defines, in a feebler degree, the angles in the opposite direction. The length of this metacarpal is 1 inch 7 lines; the breadth of the distal end is 1 inch 8 lines. The upper surface is smooth, broad, and almost flat. The radial surface is continued into the thenal one, which is strongly concave lengthwise, and these combined surfaces are roughened by longitudinal ridges and grooves.

The ulnar surface slopes in that direction strongly from the upper one to meet the combined theno-radial surfaces; the distal articular surface is trapezoid in form, convex vertically, slightly concave transversely at its middle part, and continued upon a pair of tuberosities thenally; the toe which it supported would be directed obliquely to the ulnar side of the foot.

The skeleton of the fore-paw of the Iguanodon, carpus inclusive, may be set down as about 16 inches in length, and about 11 inches in extreme breadth, showing a like disproportion of size to the hind-foot which the humerus does to the femur.

In the Supplement,[1] No. 1 ('Restoration of the (Hind?) Foot of the Iguanodon'), p. 373, I remarked, in regard to its subject, "the resemblance to the hind-foot of the *Crocodilia* in the suppression of the fifth toe, and the resemblance of the third and fourth toes, in regard to their nearly equal length, to those toes in the Monitor, render it most probable that the tridactyle foot of the Iguanodon, here described, is a 'hind-foot;' but it cannot be assumed that the fore-foot may not have been similarly modified" (ib., p. 375.)

We have now the desired evidence, and know that the fore-foot was pentadactyle, and that its chief speciality is in the stunted character of the terminal phalanges, at least of the second and third digits. The entire length of the bony framework of the fore-foot, without the carpus, is 1 foot 1 inch; its breadth across the proximal ends of the metacarpals is 9 inches: the length of the bony framework of the hind-foot, without the tarsus, is 1 foot 8 inches; its breadth across the proximal ends of the metatarsals is 9 inches.

The fore-foot is smaller in proportion to the hind-foot in the Crocodile; it is still smaller in the Iguana.

The length of the bony framework of the hind-foot in a *Crocodilus biporcatus*, with a

[1] Vol. of the Palæontographical Society, 4to, for 1858, p. 3.

vertebral column, from the first cervical to the last sacral inclusive, of the length of 3 feet 2 inches, is 8 inches, including the tarsus; the length of the fore-foot, including the carpus, in the same skeleton, is 5 inches 4 lines.

In the skeleton of an *Iguana*, with the same part of the vertebral column 9 inches 3 lines in length, the length of the hind-foot, including the tarsus, is 4 inches 5 lines; that of the fore-foot, including the carpus, being 2 inches 3 lines.

In most recent *Reptilia* the fore limbs are shorter than the hind ones; in some of the tailless Batrachians the difference is extreme. But there is nothing in the proportions or structures, especially in the approach to the ungulate type of the unequal phalanges of the fore-foot of the Iguanodon, to justify, encourage, or even suggest that the fore limbs so terminated did not take their share, as in the Iguanas and Crocodiles, in terrestrial locomotion.

The notion of the Iguanodon being a biped, and walking like a bird, would, were it true, lend countenance to the reptilian hypothesis of the Ornithicnites.

But this notion would imply, not only ignorance of the structure of the fore limbs of the huge reptile, but also forgetfulness or disregard of the correlated conditions of avian bipedal progression on dry land.

In proportion to the bulk and weight of the bird, and to its limitation to terrestrial locomotion, is the extent of the trunk-vertebræ grasped by the splints or side bones ('ilia'), which transfer the weight of the body upon the hind limbs. Thus, the ostrich has twenty coalesced sacral vertebræ.

We have no evidence that the Iguanodon had more than four sacral vertebræ, and our knowledge of their characters is derived, as might be expected from the remains of a cold-blooded prone quadruped, from detached and unanchylosed sacral centrums.

Observation of the genesis of the bird's sacrum showed,[1] among other points, the alternating disposition of the central and neural elements; and progressive research into the osteology of the extinct *Reptilia* led to the recognition of a correspondence in this particular of the sacrum of the large Dinosaurs with that of Birds. But this afforded no ground to the Discoverer of the sacral structure for affirming or predicating a closer affinity of the Iguanodon or Megalosaur than of the Pterodactyle to the feathered class.

In the strong ligament of the head of the femur in Birds—in the depth of the socket for its reception—in the strength and close adjustment of the knee-joint, in which the fibula takes its share—in the well-turned trochlear form of the distal end of the tibia—in the rejection of any intermediate tarsus between it and the foot, and in the consolidation of the metatarsal bones for a firm and close articulation with the tibia, we may discern a perfect adaptation to the requirements of the single pair of limbs to which the functions of support, station, and progression on land, are exclusively confided.

[1] Owen, 'On the Archetype and Homologies of the Vertebrate Skeleton,' 8vo, 1848, p. 159, fig. 27; 'Catalogue of the Osteological Series in the Museum of the Royal College of Surgeons,' 4to, 1853, p. 266.

The reverse of all these conditions is seen in the bones of the hind limbs of the Iguanodon and other Dinosaurian reptiles.

If one takes the pleasure of speculating on the genesis of *Didus* or *Dinornis*, guiding or reining the roaming fancy by facts, the geographical limitation of such ornithicnitoid species, and their primitive association exclusively with creatures of which they could have no dread, suggest the more obvious and intelligible hypothesis of derivation from antecedent birds of flight, whose wings they still show more or less aborted, according to Buffon's principle of transmutation by degeneration,—with a progressive predominance of the legs over the wings, ultimately resulting in a maximization of the terrestrial and abortion of the aerial instruments of locomotion.

Mandible and Mandibular Teeth ('Dinosauria,' Plates 49, 50).

The dentary element of the right mandibular ramus of the young Iguanodon (*Dinosauria*, Plates 16, 17), discovered in the Wealden of Stammerham, near Horsham, Sussex, by G. B. Holmes, Esq., demonstrated the fact that the sculptured surface of the crown in the teeth of the lower jaw was turned inward, the smooth surface outward, toward which aspect the entire tooth was moderately bent. Moreover, the alveoli in that jaw showed eighteen teeth to be the number supported in a close-set series and working position in the dentary element (*antè*, p. 296).

The portion of mandible obtained by S. H. Beckles, Esq., from the locality of the limb-bones above described, is also the dentary element of the right ramus, of which a figure of the inner side is given in *Dinosauria*, Plate 49. On this surface the crowns of seven teeth nearly risen into place are seen; the worn crown and fang of a few of the preceding generation of teeth have been preserved, and the summits of the crown of a few teeth of a third set in succession is seen in the interspaces of the more developed teeth of the second set.

The length of the portion of mandible here preserved is eighteen inches; that of the corresponding part of the mandible of the Iguanodon discovered by Captain Brickenden in the Wealden of Filgate (*Dinosauria*, Plate 18) measures 20 inches. It is probable, therefore, that Mr. Beckles' specimen had nearly attained the full average size of the great herbivorous reptile.

The antero-posterior breadth of the teeth rising into place averages 9 lines; the largest mandibular teeth of *Iguanodon* (*Dinosauria*, Plate 45) give 1 inch in the same dimensions. The crown-germs of the teeth in the Stammerham jaw (*Dinosauria*, Plate 16) average 6 lines; we thus learn that each successive series of teeth had an increase of size corresponding in a general degree with the growth of the jaw.

The subject of fig. 1, Plate 49, shows at its interior or symphysial end the abrupt slope downward of the short, edentulous, compressed part, which curves inward to meet the corresponding part of the opposite ramus at a short symphysis, extending along an hori-

zontal surface, parallel with the straight lower border of the mandible. The smooth canal thus formed above the symphysis indicates a relation of facility in regard to the movements of protrusion and retraction of a long, cylindrical, muscular tongue, probably used, like that of the Giraffe and Megatherium, for the prehension of the vegetable substances selected by the Iguanodon for food.

The commencement of the coronoid process, contributed by the dentary, is the same in extent as that shown in the younger Iguanodon's jaw (*Din.*, Plate 16, *a*, *f*), and indicates the position of the suture of the dentary with the surangular element.

The surface of the tooth-crowns here exposed show the submedian primary vertical ridge (*a*), which, in detached teeth, indicates the hinder border of the crown by its proximity thereto. The secondary ridge (*b*) is faintly marked, but is best shown in the two hindmost teeth. The anterior lamello-serrate border describes the usual convex curve; the posterior border being almost straight or slightly concave along its chief extent. The dental characteristics of *Iguanodon Mantelli*, as illustrated in previous plates (*Din.*, Plates 23, 45), are well maintained. The secondary ridge is, however, less developed than in the larger teeth of older Iguanodons. The alveolar border here, as in the smaller jaw, describes a gentle sigmoid curve in the transverse direction, the convexity being inward in the hinder two thirds, then straight or slightly concave to the commencement of the symphysial slope.

In the inwardly convex part of the alveolar tract the teeth are placed 'en echellon;' the fore-and-aft plane of the anterior tooth (*Din.*, Plate 49, fig. 1, *a*), if carried back, would pass outside the succeeding tooth (ib., *b*), and the crown of this stands in like relation to the next tooth behind (ib., *c*). Thus, when fully in place, the crowns slightly overlap in the lower as in the upper jaw (*antè*, *Din.*, Plate 45, fig. 2), and thus, eighteen teeth may range along an alveolar tract, which, if each tooth stood clear of the next, would not support more than fourteen. Room is also got for the full number along the working line by a certain alternation in the degree of attrition, as is well exemplified in the portion of mandible of a younger *Iguanodon* next to be described (Plate 50).

I am indebted to A. J. Hogg, Esq., for the opportunity of examining and figuring this instructive specimen. It was discovered in the hard limestone, locally known as the "Under Feather," which is situated from four to five feet below the accumulation of shells of *Ostrea distorta*, called the "Cinder Bed," in the Middle Purbecks.

A reference to p. 22, fig. 4, of my 'Monograph on the Fossil Mammalia of the Purbeck Formations, British Mesozoic Mammals' (Palæontographical Society, vol. xxiv, issued for 1870), will show the position in the Middle Purbeck series in which the present interesting evidence of the *Iguanodon* was entombed. It is the first example of that genus, to my knowledge, from the Purbeck series.

In making this statement I refer, of course, to the unequivocal evidence of Iguanodon afforded by the dentition. A large phalangeal bone is figured by Buckland in Pl. XLI, 'Geological Transactions,' Second Series, as a "metacarpal" of Iguanodon. It was picked up "on the sea-shore, about half a mile north of the village of Swanwich" (ib., p. 428), and though "more or less injured by rolling on the sea-shore" has most claim to be referred to the hind-foot of the Iguanodon. It was most probably washed out of the cliffs of iron-sand and sandy clay described by Webster as dividing the Greensand of Ballard Down from the upper body of the Purbeck "limestone."

The portion of jaw here exposed (Pl. 59, fig. 8), is the dentary element of a right mandibular ramus, about the size of the Stammerham specimen (Plates 16 and 17), but is mutilated at both ends; it includes, however, in an alveolar tract of four inches, ten teeth, alternately young and old. The foremost, *b*, is a lanceolate and acuminate crown-germ, least advanced in size and lowest in position in the jaw. The second, *a*, is fully in place with the upper third of the crown worn away and supported by a long, slender, tapering fang, occupying the interspace between the first and third teeth. The latter shows the crown fully formed, with the apex risen almost to the level of the worn surface of the antecedent tooth, between which and the fourth it accurately fills the interspace. The fourth tooth, *a*, rises to a higher level than the second and has rather more of the crown worn away; much of its narrow fang is exposed. The crown of the fifth tooth—third of its series *b*—fills, like the third tooth—second of the series *b*—the interval between the fangs of the fourth and sixth teeth. The sixth tooth rises a little higher than the fourth, and is rather more worn. The seventh tooth—fourth of the series *b*—is more complete and rises higher than the fifth or third; the apex of its crown is on a level with the worn surface of the sixth tooth: the outer part of the lower half of the crown and beginning of the fang of the seventh tooth has been broken away, showing the pulp-cavity in the latter. The eighth tooth—fourth of the series *a*—is worn down to the contracted base and beginning of the fang. The ninth tooth has risen above it, has come into service, and the crown is supported by a strong root. Beyond this is part of the crown of a successional tooth of a third series, *c*.

The close interlocked fitting of these teeth of different stages and periods of growth is most instructively shown in the present specimen; former ones had given only a partial view of this arrangement, suggestive, however, of an Iguanodontal character of dentition, which is here demonstrated.

The primary and secondary ridges are more equally developed, and the tertiary ridges less conspicuous, in these lower teeth of a Purbeck *Iguanodon* than is usual in the larger or older Wealden specimens. If any Palæontologist should see in this a specific character he may, perhaps, accept the name of *Iguanodon Hoggii*.

SKULL AND TEETH OF *Iguanodon Foxii*. ('Dinosauria,' Plate 59, figs. 9, 9 *a*, 10; Plate 60, figs. 1, 5, 8—18).

This unique specimen, for the opportunity of describing which I am indebted to the discoverer, the Rev. W. Fox, M.A., throws much light upon the cranial characters of the Iguanodon.

The articular or condylar part of the basi-occipital (*Dinosauria,* Pl. 60, fig. 1, 1) is broken away, a portion of the broad basilar part of the bone (ib., fig. 5, 1) remains in articulation with the basi-sphenoid (ib., ib., 5). This element shows a median contraction with lateral emarginations, bounded anteriorly by the pair of pterapophyses (*t*, *t*). The left of these abuts in its natural position against the corresponding pterygoid, the hinder branch of which, diverging obliquely backward, is broad and moderately concave on its postero-internal surface; the end which would have abutted upon the inner and back part of the tympanic is broken off. There is no apparent "pre-sphenoid style" from the interspace of the pterapophyses.

The left half of the foramen magnum (*Din.*, Pl. 60, fig. 1 *f*) is entire, showing a vertical diameter of 4 lines, a transverse one of 5 lines; the lower part shows the fractured surface from which the left exoccipital portion of the occipital condyle has been broken away: the basi-occipital part of the condyle is wanting. The super-occipital (ib., ib., 3) rises broadly and vertically from the upper half of the foramen, *f*, for an extent of 6 lines; a tract of matrix of ·3 lines extent intervenes between the super-occipital, which here shows a jagged upper margin, and the hind border of the parietal, 7. It may be, as in *Varanus* (ib., fig. 2), that an unossified tract of the cranial walls has been left here; or an angular ridge, as in the Crocodile (ib., fig. 4, 3), may have been broken away. The direction of the occipital surface is more vertical than in Lizards. The mid-tract of the super-occipital is moderately convex transversely, the lateral tracts as moderately concave to the lateral borders of the occiput, which borders gently converge as they rise (*Din.*, Pl. 60, fig. 1, 3). The exoccipitals (2) extend, connately with the par-occipitals (4), outward, slightly downward and backward, for an extent of 9 lines from the foramen magnum, preserving a vertical breadth of 4 lines.

In *Iguana* (Ib., ib., fig. 3) the super-occipital (3) is a vertical crest, from which the sides slope forward and outward at an acute angle. In *Varanus* (ib., fig. 2) the super-occipital surface (3) is transversely convex and strongly inclined from the foramen magnum (*f*) upward and forward. The small Dinosaur, like *Dicynodon,* shows a crocodilian type of the occiput.

The left tympanic (ib., fig. 1, 28) has been dislocated inward, and lies with its upper end beneath the par-occipital abutment (4).

The pterygo-palatine structures accord with the lacertian type. The proportions of the pterapophyses (ib., fig. 5, *t*) are more like those of *Varanus* (ib., fig. 6, *t*) than of *Iguana* (ib., fig. 7, *t*); but the pterygoid of the small Dinosaur resembles that bone in the herbivorous Lizard. The right pterygoid (fig. 5, 24) retains part of the tympanic process (*a*) and of that (*c*) which abutted against the ectopterygoid (25); a portion of the right palatine (20) is preserved, of small size, showing an anterior and posterior emargination, as in *Varanus* (ib., fig. 6, 20). The hind end of the right maxillary with the abutting part of the ectopterygoid are broken away in the fossil. The right malar bone has left its impression on the matrix (Pl. 59, fig. 9, 26).

The masto-postfrontal zygoma (ib., 8—12), in its breadth and relative position to the occiput and parietal, is crocodilian. The normal or lower (malo-squamosal) zygoma is indicated on the right side by the impression of the malar and a remnant of the squamosal; a larger proportion of which is preserved on the left side (Pl. 60, fig. 1, 27) abutting against the tympanic (ib., 28). It is also shown in Pl. 59, fig. 9 *a*, where the parts are drawn without reversing. The upper outlet of the temporal fossa is smaller than in Lacertians, larger than in existing Crocodiles; its proportions are those of some Teleosaurs and Dicynodonts, and are approached by those of the small Crocodilian from the same Wealden locality (ib., fig. 24, *t*, *t*).

The skull of *Scelidosaurus*, which gave the first considerable insight into the type of that part of the Dinosaurian skeleton, had, unfortunately, lost so much of the fore-end as prevented the application of the external narial test of its correspondence with one or other of the two existing divisions of Brongniart's *Sauria*. It could not, thereby, be determined, for example, whether the outer part or process of the fore-end of the nasal applied itself to the anterior edge of the ascending process of the maxillary, or to that of the premaxillary; in other words, whether the maxillary entered into the formation of the outer nostril, as in *Lacertilia*, or was excluded therefrom, as in *Crocodilia*.

The present Dinosaurian skull supplies this test and shows its correspondence with the Crocodiles; there is, nevertheless, a touch of the Lizard. For the body or jaw-part of the premaxillary (*Din.*, Pl. 59, fig. 9, 22) sends upward not only the process from its hinder part (22^{x}), applying itself to the outer border of the fore-part of the nasal (15) and excluding therefrom the maxillary (21), but it also sends upward a more slender process from the fore-part, which terminates in a point wedged between the ends of the nasals and dividing the right nostril (*n*) from the left, after the lacertian type. Yet, again, the Crocodilian affinity is here manifested, for the premaxillaries are not confluent and the dividing process is not a single and symmetrical one, as in *Iguana*, *Varanus*, and most Lizards,[1] but is bisected by the medial suture or cleft dividing the right from the left premaxillary. The premaxillary thus, in the main, adheres to the type of that of the Crocodile, circumscribing all that part of the nostril which is not due to the nasal

[1] *Hatteria* (*Rhynchocephalus*) is an exception ('Phil. Trans.,' 1862, plate xxv, fig. 5, 22, p. 467).

bone itself, and excluding the maxillary from the boundary of the respiratory opening. The application of the outer process of the fore-end of the nasal to the anterior edge of the ascending process of the maxillary could only be predicated by one mistaking a crack of the premaxillary for the suture. The ascending process (Ib., ib., fig. 9, 22^x) with which the nasal articulates at the outer part of its fore-end belongs to the premaxillary as well as does the inner process of the same end of the nasal bone.

The premaxillo-maxillary suture extends from behind the sixth obvious premaxillary tooth for the extent of nearly an inch, with a slight curve convex forward, between the two main elements of the upper jaw. The maxillary and premaxillary have been slightly separated from each other along this suture by the force which has fractured both bones; but the margins of the suture show its true nature and distinguish it from the fractures, especially those on the body of the premaxillary, one or other of which must be adopted for a suture on the hypothesis of the hinder ascending process (22^x) belonging to the maxillary bone.

Of the six premaxillary teeth in place the foremost alone (Ib., ib., fig. 9, *i*) has the crown entire; its outer surface is convex across and lengthwise, most so along the middle, transversely, the main or mid-ridge of the Iguanodontal teeth being thus indicated. The margins are also slightly relieved (*Din.*, Pl. 60, fig. 18, magn.) and converge at an acute angle to a sharp, slightly incurved, apex; the enamel is minutely punctate. Neither in the right nor the left deflected part of the premaxillary, anterior to the pointed tooth, is there any trace of socket or fang. It would seem that this end of the premaxillaries was edentulous, like the corresponding slope of the symphysial part of the mandibular rami to which it was applied. The outer surface of the deflected ends of the premaxillaries is pitted and finely punctate or rugose.

The fractured bases of the premaxillary teeth succeeeding the first show a transverse diameter nearly eqnal to the fore-and-aft one, and I can form no judgment as to the shape of their missing crowns, save on the analogy of the Iguanodon. They are close-set, and if those crowns extended antero-posteriorly they must have overlapped. This Iguanodontal arrangement is demonstrated in the undisturbed maxillary teeth, of which eight are recognisable; the hind border of one crown overlaps the fore border of the tooth behind.

The two anterior maxillary teeth have slipped in part from their sockets and do not show this arrangement. The first is the smallest antero-posteriorly, but its crown has been worn to the fang, and when entire would be larger in that direction. The second tooth is less worn, and yields in size to the third. In the fifth the full size of the crown, antero-posteriorly, is shown, and this tooth is selected for the magnified view in Pl. 59, fig. 10.

The outer surface of the crown is bisected by a medial primary longitudinal ridge; behind this ridge the surface is smooth and concave transversely; in front of the ridge the similarly concave surface is accentuated by two low secondary longitudinal ridges.

The same characters appear, in the degree in which the crown is unworn, in the other maxillary teeth.

In upper or maxillary molars of *Iguanodon Mantelli* the following varieties have been recognised and figured.

In the specimen figured in Pl. 23 (*Din.*), fig. 2, the primary ridge is nearer the fore border of the crown than in fig. 10, Pl. 59, of the present species; there is a feeble indication of a secondary ridge on the anterior transversely concave facet. There are two secondary ridges in the posterior facet, and the crown is so worn down as to show no trace of marginal serrations.

In the upper tooth of *Iguanodon Mantelli* (*Din.*, Pl. 23, fig. 2, *m*), the crown is less worn than in *Iguanodon Foxii*, and the marginal serrations appear beyond the line of extreme breadth. The anterior facet shows no secondary ridge; the two such ridges in the posterior facet run together in the terminal part of the crown.

In *Din.*, Pl. 45, fig. 2, three upper molars are shown *in situ* with the Iguanodontal overlap, viz. the hind border of a fore-tooth (*m*) over the fore-border of the next tooth (*n*): in these upper molars the primary ridge is sub-medial, and the front face smooth as in fig. 10, Pl. 59; the two secondary ridges on the hind facet are feebly indicated. The marginal serrations are shown in the preserved terminal part of the crown, which is entire in the teeth marked *n* and *o*. Bisect the tooth *n* at the line at which it is worn away in figs. 9 and 10, Pl. 59, and no serrations would appear. In some upper molars of Iguanodon the margino-serrate character is continued in a minute form nearer to the base of the posterior margin. I have figured a left upper molar of this variety in figs. 2, 3, 4, of Pl. 59 (*Din.*), and also to show the further variety of three secondary ridges on the hind facet of the crown.

But the upper molars in the subject of fig. 9 show, as in the enlarged view (fig. 10), a continuation of the relieved or raised lateral borders across the base of the crown, in a curved course, convex toward the fang. This basal ridge does not project beyond the origin of the primary ridge, but falls into that origin.

I have not observed this character, at least so definitely marked, in any upper tooth of *Iguanodon Mantelli*, and I regard it as indicative of a specific distinction of the smaller Iguanodon now under review, believing myself entitled to conclude as to its generic relationship from the characters of the dentition of the upper jaw above defined and illustrated.

It is true that one, at least, of the premaxillary teeth is canine-like. But no portion of the skull of *Iguanodon Mantelli* has yet been discovered which would supply the means of testing its resemblance to or difference from the smaller species, in regard to this dental character. Consequently, prior to our knowledge of the skull and dentition of the smaller species, the discovery of a tooth answering in size to the ordinary upper molars of *Iguanodon Mantelli*, but with a lanceolate and acuminate crown, would naturally suggest its reference to some other Dinosaurian genus of the Wealden, of the bulk of the

Iguanodon. In giving a description of this tooth (pp. 420, 421, figs. *a*, *b*, *c*, p. 422) before the present discovery of the upper jaw and teeth of an Iguanodon was made, I suggested that it might belong either to *Cetiosaurus* or *Pelorosaurus*. I now, however, from its resemblance to the entire premaxillary tooth in the small Iguanodon—as close as is the resemblance in the maxillary teeth—deem it more probably to belong to the larger species and to be a premaxillary tooth of *Iguanodon Mantelli;* and I now add two views of this tooth of half the natural size are given in *Din.*, Pl. 60, figs. 19 and 20, to facilitate comparison with the magnified view of the laniary of the smaller species (fig. 18). The surface of the crown (fig. 20) which answers to the outer one in fig. 18, and in *i*, fig. 9, Pl. 59, is convex both lengthwise and transversely, and most so in the latter direction along the middle part; the main or mid-ridge of the maxillary Iguanodontal teeth being thus represented. On the opposite (inner) side of the crown (fig. 19, Pl. 60) the surface is concave across the two thirds next the apex. One margin, the anterior according to the analogy of the small Iguanodon, is convex, the hinder margin along its terminal half is slightly concave. The crown expands antero-posteriorly above the root to nearly midway to the apex, towards which the borders then converge to a point with the different contours above noted. Both borders are trenchant, not serrate.

Now that we know that a laniariform, or 'lanceolate and acuminate,' premaxillary tooth was associated with molars of the Iguanodontal type, in a small exemplar of the genus, we may anticipate that the premaxillary part of the skull of *Iguanodon Mantelli*, when discovered, will show teeth, if they should be preserved there, of the laniary type exemplified in p. 422, *a*, *b*, *c*, and in Pl. 60, figs. 18, 19, and 20. The anterior mutilation of the skull of the *Scelidosaurus*, with maxillary teeth having the terminal and more expanded half of the crown serrate (Pl. 60, fig. 21), precludes, at present, the determination whether the iguanodontoid molars of this genus were similarly associated with anterior laniaries. But the dentition of the small Purbeck Dinosaur (*Echinodon*), with a corresponding type of maxillary dentition (Pl. 60, fig. 22), does include one or more laniaries in advance of molars of the serrate type, as in the small and large Iguanodons ('Monograph on the Fossil Reptilia of the Cretaceous and Purbeck Strata,' Pal. Soc. vol. for year 1858, p. 35, Pl. VIII, figs. 1, 1 *a*).

I next proceed to determine how far the dentition in the small skull repeats the iguanodontal character of overlapping arrangement of the crowns of the teeth.

The right tympanic and mandibular ramus are wanting in the fossil. The left mandibular ramus has been pushed obliquely to the right side, and its fore end has partly displaced the first and second molars, beyond which the projecting end has been broken away. The crowns of those teeth, so driven out of line, are thereby partly withdrawn from their sockets, so as to expose the basal half of their fangs. From this I infer that the force has operated upon the recent animal: for, if it had acted subsequent to fossilisation, through movement of the matrix, it would

have broken the teeth, at that time cemented to their sockets. Howsoever that may be, displacement is obvious, and no inference can be drawn as to the original relative position of the crowns of these anterior teeth. As it is, the anterior edge of the crown of the third molar does not overlap in the slightest degree the posterior edge of the crown of the tooth before it; the reverse is the case if any overlap at all can be predicated. In the undisturbed molars the hind edge of each tooth projects a little beyond the fore edge of the one behind it. This is the characteristic arrangement of the upper or maxillary teeth of *Iguanodon*. It is exemplified in the specimen figured in *Din.*, Pl. 45, fig. 2, in the undisturbed upper teeth, there marked *m, n, o*. The overlap by the anterior edge of the crown in the anterior four maxillary teeth of the posterior edge of the tooth in front, and the reverse arrangement in the rest of the maxillary series, may be a character of *Hypsilophodon*, Huxley, but is not one of the present nor of any previous evidences of *Iguanodon*. In the small species discovered by Mr. Fox, as in the large type of the genus, the maxillary grinders not merely seem to overlap, but do so, in the way and degree exemplified in fig. 9, Pl. 59, and in fig. 2, Pl. 45.

Four or five teeth may have occupied the alveolar interspace between the foremost of the series of ten maxillary teeth and the second tooth from the premaxillary one, *i* (Pl. 59, fig. 9). Sixteen teeth of the pattern characteristic of the upper molars of *Iguanodon* would thus occupy the extent of the alveolar border of the upper jaw preserved behind the pointed tooth (*i*). The maxillary is broken away behind such sixteenth molar. The small Iguanodon may, therefore, have resembled the large one, in number or 'formula,' as in the characteristic and peculiar generic pattern, of its teeth. The arrow (10) points to the tooth which is the subject of the magnified view (fig. 10). A comparison of this figure with a similar magnified view of an upper molar of *Scelidosaurus* (*Din.*, Pl. 46, fig. 3 [1]) shows the teeth of the two genera to be modifications of the same type. The exterior surface of the crown in *Scelidosaurus* (Pl. 60, fig. 21) has a median and two marginal longitudinal elevations or ridges. The marginal ones diverge with the expansion of the crown, and end in points at its extreme breadth, rather more than half way between the base and apex of the crown. This apex and the points of the marginal ridges define a triangle, the converging sides of which are notched or serrate. The hollows between the medial and marginal ridges are smooth in *Scelidosaurus*, the anterior hollow is usually ridged in *Iguanodon*. In this genus the 'secondary' ridges are more feeble than the primary ones, and are plainly the seat of variety, as in the instances above cited. The upper molars of the small Iguanodon (Pl. 59, figs. 9, 10) exemplify the rule of the generic type: fig. 2, Pl. 45, shows the variety more approaching the type of the geologically older Dinosaurian (*Scelidosaurus*).

The molars of the Purbeck Dinosaur (*Echinodon*, Pl. 60, fig. 22) repeat the pattern of those of *Scelidosaurus*, but the marginal serrations, being more numerous and relatively

[1] Pal. Soc. vol. for year 1859.

smaller, more resemble the serrations which the propounder of the genus *Hypsilophodon* erroneously states "are so characteristic of the teeth of Iguanodon."[1]

The tooth, which I have referred, with probability, to the *Hylæosaurus*, shows the shape of crown on which the Scelidosaurian and Iguanodontal patterns have been superinduced; it expands from the base to two lateral angles, whence the sides converge to a third apical angle. If the converging borders of the terminal half of the crown had originally been notched or serrate, those projections had been worn away by use, in the tooth figured ('Monograph on the Fossil Reptilia of the Wealden Formations: Genus *Hylæosaurus*' in the Palæontographical Society's volume for 1856[2]). I may remark, also, that this tooth is a mandibular one, and that a nearer approach to the serrident type may have been shown in the maxillary teeth of the *Hylæosaurus*. Howsoever this may prove to be, the conformity of cranial structure, as of fundamental tooth-type, between *Scelidosaurus*, *Echinodon*, and *Iguanodon*, now exemplified by the small skull (Pl. 59, fig. 9), makes it convenient to associate the genera in a section of *Dinosauria*, which may be termed '*Prionodontia*,' *i. e.* serrident, or saw-toothed.

In this family the skull exhibits a more generalised type of structure than in the existing *Crocodilia* and *Lacertilia*.

The short, square, massive character of the cranium, and the greater extent of ossification of the rest of its walls, are retained in modern *Crocodilia;* but the majority of the characters, as the double or divided external nostrils, the divided frontals, the relatively large orbits, the pterygoids divaricated by intervening basi-sphenoidal pterapophyses, and the separated palatines, are characters retained by modern Lizards. In the majority of existing Lacertian genera, however, the nasals form a single bone, and the premaxillaries are confluent anteriorly. These bones retain their parial condition in *Crocodilia* as in *Prionodontia*.

The position of the portion of lower jaw—left mandibular ramus—preserved in the block of matrix with the skull, precludes the procedures of exploration requisite for detection of teeth or germs of teeth, with any regard for the safety of the rest of this unique specimen, although the temptation is great, in reference to the alleged absence of an Iguanodontal characteristic, namely, the serrations of the free edge in the teeth of this specimen. Not that the allegation has any real value as to the generic character of the Saurian so represented; since it is plain that the remnants of the crowns of the upper molars are not such as could show the Iguanodontal serration if it had existed, the apical part being wanting where alone, as a rule, the crown is marginally serrate in the upper molars of *Iguanodon Mantelli*. In this species, moreover, the serrations are more numerous, and affect a relatively greater extent of the margins of the crown in the teeth of the lower jaw than in those of the upper. Hence it might be expected that the mandibular teeth of the small species from the Cowlease Wealden would apply a decisive

[1] 'Quart. Journal Geol. Soc.,' vol. xxvi.

[2] P. 21.

test, on the assumption that the absence of marginal serrations—all other Iguanodontal characters present—was decisive against a generic relationship with Iguanodon.

Mr. Fox has kindly transmitted to me the portion of the left mandibular ramus, 1 inch 7 lines in length, with a depth of 7 lines, where entire, which is the subject of figs. 8—11 in Pl. 60. It includes the sockets and fangs of eight teeth, so closely set as to have necessitated the overlapping arrangement of the crowns, according to the Iguanodontal type, the hind margin of the anterior tooth covering the outer side of the fore margin of the tooth behind, in the lower as in the upper jaws. The proportion of transverse to fore-and-aft diameters of the fractured bases of the mandibular teeth (fig. 8) in this specimen is also Iguanodontal, suggestive of a bruising function. These eight teeth occupy an alveolar extent of 1 inch 3 lines.

The outer surface of the ramus (ib., fig. 9) is divided into an upper and lower facet by a low, obtuse, prominent angle or ridge extending horizontally, and giving the greatest thickness to that part of the jaw; a series of five vascular or neuro-vascular foramina extends a little above this ridge. The structure of the outer surface of the ramus, exhibited by the larger jaw of a young Iguanodon, also discovered by Mr. Fox, in the same Wealden deposits of the south-west coast of the Isle of Wight, closely accords with that shown by the present specimen (compare *Din.*, Pl. 24, fig. 4, with Pl. 60, fig. 9).

In like manner the inner surface of the smaller mandibular fragment (ib., fig. 10) shows a gentle convexity lengthwise and an almost level surface vertically, broken by a longitudinal groove near the lower border.

Concluding that, as in *Iguanodon*, the germs of successional teeth would lie on this side of the roots of the broken ones which had been in use, and that such germs would have the 'lanceolate and acuminate' portion of the crown, yielding the required test of conformity or otherwise in regard to marginal serration, I removed the inner (splenial) plate at parts which exposed three such germs (Pl. 60, fig. 11, *a*, *b*, *d*), each demonstrating the character in question.

The inner side of the crown is traversed longitudinally by the submedial primary ridge, the coronal margin anterior to which shows four acute serrations, with grooves continued from their intervals some way down the surface. The extreme fragility of these precious evidences checked further attempts to expose more of that surface. My interpretation of the characters of the mandible and mandibular teeth, so far as they are exhibited by this specimen, is, that they demonstrate a reptile of the genus *Iguanodon*.

If the specimen belong to a full-grown individual, the greater relative size and the smaller number of the coronal serrations show it to belong to a distinct species of *Iguanodon*, for which the name of its discoverer is deservedly to be retained.

Still may remain the question whether, in the numerous successions of teeth which would ensue during the acquisition of the magnitude of *Iguanodon Mantelli,* the number of serrations might not be increased in greater proportion than the increase of the size of

such serrations. That would be the sole modification needed to make them specifically as well as generically the teeth of *Iguanodon Mantelli.*

Of the above-described mandibular fossil Mr. Fox writes:—"This jaw was found within a yard of the skull. They were both in a mass of mud that had slided down from the cliff, and was being gradually washed away by the sea."

What is wanting in the exposed portions of the tooth-germs in the above specimen, viz. the continuation of the marginal serrations, of smaller size, upon the ridge bending from the margin at the broadest part of the crown upon the inner surface of the narrowing basal part of the crown, is fortunately supplied by an almost entire lower molar of *Iguanodon Foxii* (Pl. 60, figs. 12—17), which came from a slab of Wealden stone containing a portion of a right mandibular ramus (Woodcut, fig. 1), with the symphysis, *s*, confined to the lower border of the sloping end (as at 5′, fig. 1, Pl. 59); also a few ribs, a caudal vertebra of the pattern of those figured in Pl. 7 (*Din.*), and also "a distal phalanx of one of the toes." "I cannot tell," writes Mr. Fox, "where I have the bone itself, but its shape is exactly like that in *Iguanodon Mantelli,* very little curved in a downward direction, and rather broad.[1] In the little paper box, along with the fragment of jaw, you will find one very small tooth, quite perfect,[2] that came out of this slab in dressing."[3] This slab was found in the fallen cliff, about 150 yards east of "Barnes' High," directly fronting the den of my *Polacanthus,* which I dare say you will remember seeing. The skull and broken jaw were found about 60 yards further eastward."[4]

FIG. 1.

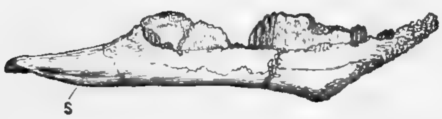
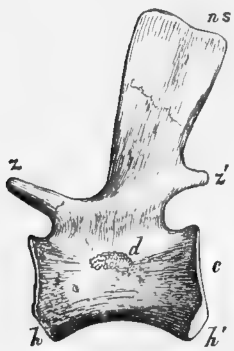


FIG. 2.



In the accompanying Woodcut, fig. 2, of the caudal vertebra, nat. size, of *Iguanodon Foxii,* are added letters of reference corresponding with those on the figure of a caudal vertebra of *Iguanodon Mantelli* (Pl. 14, fig. 1). The anterior or cervical vertebræ show the modification of the front ball and hind cup (Pl. 6, figs. 3, 4). If the sacral vertebræ should show the broad under surface, as in *s* 4, Pl. 8, a corresponding variability of vertebral shape in the same skeleton will characterise the present small kind of *Iguanodon* as it does the large kind.

The tooth (Pl. 60, fig. 12) is 5 lines in length in a straight line; it is moderately curved, with the convexity (as the teeth *in sitû* above described show) towards the inner surface of

[1] The shape and proportions of the ungual phalanges vary in the toes of the fore and hind feet in *Iguanodon Mantelli.*

[2] Letter received 4th February, 1870. [3] Ib. ib.

[4] Letter above cited. The skull and broken jaw are the subjects of figs. 9 and 9 *a*, of Pl. I.

the jaw, the sculptured surface of the crown having the same aspect. The length of the fang is 3 lines, that of the crown is 2 lines, but the apex of this has been broken off. The breadth of the crown is $2\frac{2}{3}$ lines; the thickness of its base $1\frac{1}{2}$ lines. The fang tapers to its implanted end, which is hollow and filled with matrix, subcircular in form, $\frac{1}{2}$ a line in diameter; the dentinal wall is here very thin. The fang expands towards the crown, chiefly in the antero-posterior direction, and is shorter on the outer concave than on the inner convex side, the coronal enamel descending rather lower on the outer side. The inner side of the fang is broader and less convex across than the outer side, towards which the fang seems to be, as it were, rather pinched in.

The outer side of the crown (Pl. 60, fig. 17, magn.) begins with a feeble rise of the enamel from the level of the fang, such rise describing a slight convexity downward; this side of the crown is gently concave lengthwise, more strongly convex across; it is relieved by low ridges continued down from the apices of the chief serrations, most of them subsiding before gaining the basal line. The finer serrations on each margin of the crown, where it bends in from its broadest part, are conspicuous. Minute, short, irregular, longitudinal, linear risings of the enamel may be seen with the pocket lens in part of the interspaces of the longer and plainer ridges. The crown expands to its extreme fore-and-aft breadth about one third of its length from the fang.

The enamel on the inner side of the crown (ib. fig. 15, magn.) begins by a like definite rise from the level of the fang, but this runs straighter across before bending up to the margins of the expanding basal part of the crown. The continuation to the hinder border is more prominent and its termination is more abrupt, giving a slightly angular contour to that border, and making the surface of the crown between the border-ridge and the primary longitudinal ridge a little concave transversely. The basal rising subsides more quickly and completely upon the anterior border, which describes a gentle convex curve, and does not rise so as to render the inner surface of the crown between it and the primary ridge concave. Thus, the inner and outer sides of the crown being determinable by their difference of sculpturing, the fore and hind borders are shown by the above specified characters, and the detached tooth can be referred, as in the case of those of the larger *Iguanodon*, by like characters to its own ramus or side of the jaw; this, in the present tooth, is the right one. The inner side of the crown of this tooth of *Iguanodon Foxii*, as in the lower teeth *in situ*, has one chief median primary longitudinal ridge, increasing in strength from its origin at the basal rising of the enamel to the apex of the crown. On the front facet a short secondary ridge begins, next the primary one, near the apex of the crown, and terminates in the point or 'serration' next to that of the primary ridge. Another secondary ridge begins at the base of the crown, and runs nearly parallel with the primary one. The margin of the crown, anterior to this ridge, shows the usual smaller serrations. On the hind facet two secondary ridges commence at the up-bent part of the basal one, run parallel with the primary ridge, gaining in prominence and breadth, and terminate in the

two stronger serrations behind the chief or apical one. Smaller serrations mark the hind border of the crown between the above and the end of the basal ridge.

Thus, all the complexities giving the generic characters of the lower teeth of *Iguanodon* are here manifested, as are those of the upper teeth in the skull (Pl. 59, figs. 9, 10). The following differences from the larger teeth of *Iguanodon Mantelli* are of specific value: the defined rise of the basal border of the coronal enamel on both the outer and inner sides of the tooth, especially the latter; the relatively larger size and smaller number of the marginal serrations; the larger relative size and more definite median position of the primary longitudinal ridge.

The latter character, however, is reached in the range of variety to which the teeth of *Iguanodon Mantelli* are subject, as may be seen in the anterior 'acuminate and lanceolate' tooth in the Purbeck Iguanodon (Pl. 59, fig. 8 *b*), and in the figs. 10, 15, 17, Pl. 45, exemplifying the characters of the upper and lower teeth of *Iguanodon Mantelli* and some of their varieties, due to age, wear, and position in the jaw.

From the above facts I conclude that the fossils discovered by Mr. Fox, and figured in Pls. 59 and 60, afford the much-needed exemplification of the cranial structure in the genus *Iguanodon*, and that they contribute to supply characters of the serrident family of *Dinosauria* which were not given in the fossil skull of *Scelidosaurus Harrisonii*, figured in Pls. 46 and 47. The importance of this addition to the knowledge of Dinosaurian structures induces me to recapitulate and enforce the passing remarks, offered in the course of my descriptions, on statements which, if true, would leave such addition still a desideratum.

Serrations of the free edge of the crown, affirmed to be "*so* characteristic of the teeth of *Iguanodon*" (Huxley, *ut supra*, p. 5), are not in any degree characteristic of that genus. They are present in the teeth of older *Dinosauria* as of contemporary genera. The Liassic *Scelidosaur* and the Purbeck *Echinodon* alike manifest the modification. The true generic dental characteristic of *Iguanodon* is the superaddition to marginal serration of ridged and grooved sculpturing of one of the surfaces of the crown of the teeth; to wit, the outer one in the upper teeth, the inner one in the lower, the sculpturing being in so broad and definite a style that the ridges can be named. This character, combined with marginal serration, in the molars of the small Dinosaur in question, and this other character of the overlap of the expanded crowns in the one direction above described, are now submitted to impartial Taxonomists as the ground of the reference of the subject of the present section to Conybeare's genus.

So singular an anomaly in the arrangement of a molar series as the reversal of the order of overlapping at its two extremes might well support a generic distinction, but would need clear and indisputable demonstration for acceptance. *Iguanodon Foxii* affords no real ground for the ascription of such an anomaly.

Genus—Hylæochampsa, *Owen.*

The subject of figs. 23—25, Pl. 60, was discovered by the Rev. W. Fox, M.A., in the Wealden of the south-west coast of the Isle of Wight. It is the hinder part of a skull of a small or young Crocodilian, showing the occipital surface (ib., fig. 23), the upper openings of the temporal fossæ (ib., fig. 24 *t*) with the orbits (*o*); and so much of the palate (ib., fig. 25) as permits of instructive comparisons with that seat of divers modifications in other *Reptilia.* A few sockets of teeth are shown at the hind end of both right and left maxillary bones.

These indicate the teeth to have been relatively as large as in *Goniopholis;* and, although it is hazardous to conjecture the shape of the crown of a Crocodilian tooth from the cylindrical root, as indicated by its socket, yet it seems to me probable that the teeth of the present small Crocodilian resembled more those of *Goniopholis* (*Crocodilia,* Pl. 7, fig. 2) than of *Suchosaurus* (ib., Pl. 5, fig. 4) or of *Poikilopleuron* (ib., ib., fig. 5).

The outer surface of the cranial bones shows a different pattern of sculpture from that in *Goniopholis;* instead of small circular pits there are short irregular ridges, which, at some parts, the postfrontals, for example, have a tendency to diverge from a reticulate centre; a number of short ridges and clefts radiate from the raised part of the border of the temporal outlet; but all these accentuations of the surface are rather feeble.

As I know of no corresponding specimen of a skull of any Wealden Crocodilian like the present, and as it offers generic modifications of parts which are comparable with Crocodilians of older and newer formations, I propose to describe the specimen as representing a new genus and species under the name of "*Hylæochampsa vectiana.*"[1]

The occipital surface (Pl. 60, fig. 23), excluding therefrom the tympanics, 28, and pterygoids, 24, is of a triangular form, with the base upward; the apex is pierced by the foramen, *v*. The breadth of this surface, taken at the mastoidean angles, 8, 8, is, to so much of the vertical diameter as includes the foramen, *f*, as three to one. The basioccipital, 1, contributes the middle four fifths of the condyle, the upper angles of which hemispheroid tubercle, due to the exoccipitals, are broken off. The centre of the condyle is feebly impressed; it projects, and is, as it were, sub-pedunculate. The basioccipital curves from the condyle forward and downward, then descends vertically to the foramen, *v*, and is ridged along the mid-line. The extent of the occiput below the foramen magnum, *f*, exceeds the part above the foramen. The exoccipitals, 2, are the largest elements of this cranial segment; they meet above the foramen, excluding the superoccipital, 3, therefrom for an extent of nearly three lines. The suture appears to be continued upward through the superoccipital, 3

[1] Gr. ὕλη, wood or weald; χάμψα, an Egyptian name of the crocodile. The specific name relates to the locality of the fossil.

but this may be due to fracture. The superoccipital develops a tuberosity at each upper angle, near its junction with the mastoid, 8. Each exoccipital swells at its outer border into two tuberosities, representing the paroccipitals of *Chelonia*, and contributing to the articulation for the tympanic, 28. The direction of the bilobed paroccipital border, 4, is oblique from above downward and inward. The tuberosity forming the angle of the mastoid, 8, projects distinct from the upper paroccipital one, 4.

In the relative extent of the paroccipital tuberosities and in the direction of their border *Hylæochampsa* resembles *Teleosaurus*, and differs from *Crocodilus*, in which the masto-paroccipital border extends from above downward and outward (ib. fig. 4), making the greatest breadth of the occipital surface to be at the paroccipitals, not at the mastoids.

There is no vacuity between the mastoid and superoccipital; a linear suture, slightly concave upward, alone divides them on the occipital surface.

The articular surface of the tympanic, 28, projects as usual, backward, beyond the plane of the occiput; the medial half only of that surface is preserved in the present fossil; it is almost vertical and very slightly convex.

The upper platform of the cranium behind the orbits (Pl. 60, fig. 24) is subquadrate, with the anterior angles rounded off. It is perforated by the pair of upper temporal openings, *t*, which are oblong-ovate, with the outer border almost straight, the inner one curved, and with the hinder or basal border slightly raised; the anterior border is depressed and continued upon the side of the cranium proper, forming the inner wall of the temporal fossa. A flat surface of bone (8, 12), equalling the breadth of the temporal opening, lies exterior to it; a narrower concave tract (11) divides the openings; the posterior surface (7) is broader than the lateral ones.

In *Teleosaurus* and allied genera (e. g. *Metriorhynchus*, *Teleidosaurus*, *Steneosaurus*, *Pelagosaurus*, &c.) the upper temporal openings are relatively larger and the surrounding flat tract of bone is of less extent than in *Hylæochampsa*, which herein more resembles the tertiary and modern *Crocodilia*, although the form of the openings is teleosauroid.

The general form of the upper cranial surface posterior to the orbits resembles, in *Hylæochampsa*, more that in *Crocodilus*, *Metriorhynchus*, and *Pelagosaurus*, than that in *Teleosaurus cadomensis* and in *Gavialis*, in which latter the breadth exceeds the length.

The orbits in *Hylæochampsa* (Pl. 60, fig. 24, *o*) are circular and better defined by the post-frontal (12) from the lateral outlets (*t'*) of the temporal fossæ than in *Crocodilus*, and herein they more resemble the orbits in *Teleosaurus;* but they are less horizontal than in *Tel. cadomensis*, and incline less to the vertical position than in *Tel.* (*Pelagosaurus*) *temporalis;* their outline is obliquely upward and outward. The prefrontal (14) and lacrymal (73) swell out a little anterior to the orbit, whence the maxillary (21) and nasals (15) continue to form the upper jaw. This recalls the character of that part of the skull in the Gavial rather than in the Crocodile.

These modern or procœlian representatives of the order *Crocodilia* differ from the *Lacertilia* in the greater extent or degree of ossification of the palate.

The 'pterygo-maxillary vacuity'[1] is large, and is bounded, as in Lizards (Pl. 60, figs. 6 and 7, *y*), by the pterygoid (24), the ectopterygoid (25), the palatine (20), and, in most genera, *Iguana*, e. g., by the maxillary (21). But the 'palato-maxillary' vacuity[2] (figs. 6 and 7, *n*) between the vomer, maxillary, and palatine, does not exist in *Crocodilia;* nor is there a trace in that order of an 'interpalatine vacuity.'[3] The 'interpterygoid' vacuity in *Lacertilia*[4] appears to be represented by the much smaller opening which serves as the 'palato-naris,' or hinder orifice of the nasal air-passages in modern Crocodilian genera.[5]

In his description of the Caen Gavial (*Teleosaurus cadomensis,* Geof.) CUVIER indicates a large vacuity, more advanced in position than the hinder nostril of modern Crocodiles, and more resembling the interpterygoid vacuity' of Lizards (Pl. 60, fig. 7, *s*). This he regarded in the Caen Gavial as the 'palato-naris.'[6]

The smaller and more posterior orifice, resembling the 'palato-naris' of *Crocodilus* and *Gavialis,* and which DE BLAINVILLE and BRONN affirmed to be the true hinder nostril in the Teleosaurs, Cuvier calls "le trou des artères," and marks with the letter *t* in pl. vii, tom. cit.

The real nature of this foramen in the Teleosaurs is pointed out in my paper "On the Eustachian Canals in Crocodiles,"[7] and the accuracy of Cuvier's determination of the 'palato-nares' in the Teleosaur, is now accepted.[8]

In some Teleosaurians (*Tel. temporalis,* Bl., *Pelagosaurus typus,* Bronn) the 'palato-naris,' instead of being broader than long, as in *Tel. cadomensis,* is narrower and is produced forward into a point, on the same transverse parallel as the pterygo-maxillary vacuities, which are thus reduced in size and, as it were, pushed aside.

In *Hylæochampsa* (Pl. 60, fig. 25) the vacuity (*y*) on each side of the bony palate is formed or bounded behind by the pterygoid (24) and ectopterygoid (25) and in front by the palatine (20), and probably by a small part of the maxillary (21), though here a portion of the antero-external part of the boundary is broken away. But sufficient remains to show that the vacuity is natural and is homologous with the "grand trou palatine" in

1 See my 'Anatomy of Vertebrates,' vol. i, p. 157, fig. 98, C, Y; "grand trou palatin" of CUVIER, 'Ossemens Fossiles,' 4to, tom. v, pt. ii, p. 133, pl. vii, fig. 4 *r*; also "trou ovale assez grand," p. 259, pl. xvi, fig. 3, *Varanus niloticus.*

2 'Anat. of Vertebrates,' tom. cit., fig. 98, D, *n.*

3 Ib., ib., fig. 98, D, *m.*

4 Ib., ib., fig. 98, D, *s.*

5 Ib., ib., fig. 98, C, *n.*

6 "La fosse nasale postérieure;" described as "très-grande," and marked with the letter *s* in fig. 4, plate vii, 'Ossemens Fossiles,' tom. cit.

7 'Philosophical Transactions,' 1850, p. 521, pls. xl—xlii.

8 E. d'Alton and H. Burmeister, 'Ueber der Fossile Gavial von Boll in Wurtemburg,' &c., 8vo, plates in fol., Halle, 1854, in which the small hinder foramen is called "die vereinigten Mundungen der Eustachischen Röhren und gewisser Sinusse im Innern der Ossis occipitis."

Teleosaurus cadomensis, and with that called "grand vide palatine" or "trou palatine postérieur" by Eudes-Deslongchamps in *Teleosaurus temporalis* (*Pelagosaurus typus*); consequently with those which I have termed 'pterygo-maxillary' and symbolised by the letter *y* in my 'Anatomy of Vertebrates,' loc. cit. The vacuities in the interspace between the two 'pterygo-maxillary' ones, bounded externally by the pterygoids and palatines, answer to the "fosse nasale postérieure" of Cuvier in *Teleosaurus cadomensis*,[1] and to the "grande fosse ptérygoïdienne, qui limite en avant les arrière-narines" of Eudes-Deslongchamps in *Teleosaurus temporalis*;[2] consequently, also, to that which I have called 'interpterygoid' and symbolised by the letter *s* in *Iguana*.[3]

It is plain that the palatal or posterior opening of the nasal passages offers no trustworthy homological character in *Reptilia*. It is anteriorly situated in *Chelonia* and *Lacertilia*, where those passages are vertical or nearly so; it is at the hindmost part of the bony palate in modern Crocodiles, and in a more advanced position, though still in the hinder half of the palate, in the mesozoic or 'amphicœlian' Crocodiles. In each of these cases it has a distinct anatomical conformation. In *Chelonia* and most *Lacertilia* (*Varanus*, e. g.) its boundary includes parts of the vomer (13), palatine (20), and maxillary (21);[4] in *Iguana* it includes, with the same bones, also a part of the premaxillary; in *Crocodilus* proper it is wholly surrounded by the pterygoids; in *Teleosaurus* the palatines combine with the pterygoids to complete it anteriorly.

With regard to the opening answering to the hinder nostril in *Teleosaurus*, we find in *Varanus* that the halves of the divided vomer also contribute to bound or form the pointed anterior prolongation of the vacuity,[5] in the formation of which, as the pterygoids take the most constant and always the chief share in *Lacertilia* and *Chelonia*, and as the vacuity so bounded does not in these reptiles serve as the hinder or palatal opening of the nostrils, the term 'interpterygoid' appeared to me to be most conveniently applicable.

In the skull of the *Varanus niloticus* figured by Cuvier[6] the presphenoid is prolonged so as to seem to divide the 'interpterygoid vacuity' into a pair; the point of the bone, however, in nature inclines upward, and does not join anteriorly either the palatine or vomerine bones. In the larger monitor (*Varanus indicus*) and in *Iguana* the presphenoid (Pl. 60, figs. 6 and 7, 9) has a like relation to the interpterygoid vacuity (ib., *s*), but is not so far produced.

Von Meyer, in his figure of the base of the skull of *Belodon Kapffi*,[7] represents the interpterygoid vacuity as divided by a longitudinal production, apparently, of the pterygoids, the lateral parts or plates of which form with the palatines the outer border

1 Tom. cit.

2 'Notes Paléontologiques,' 8vo, 1869, p. 146, pls. ix—xxiv, vi.

3 Op. cit., fig. 98, d.

4 Op. cit., fig. 98, b.

5 Cuvier, tom. cit., pl. xvi, fig. 3, &c. &c.

6 Ib., ib.

7 'Palæontographica,' zehnter Band, pl. xxxix, p. 227 (1863).

of such vacuity. The homologues of the 'pterygo-maxillary vacuities' are much reduced in size, are external and posterior to the 'interpterygoid' openings, and are exclusively formed by the pterygoid and ectopterygoid, which, uniting externally to those openings as well as internally, are interposed between the maxillary and the 'pterygo-maxillary vacuity.' VON MEYER, as usual, puts no figures or letters of reference upon the bones and orifices, nor refers thereto by means of such symbols in his text.

Assuming, however, that the usually careful and accurate delineator of fossil specimens has correctly represented the palatal characters of his *Belodon Kapffi*, it offers the nearest resemblance to the characters of that part of the skull of *Hylæochampsa*.

In the proportion of this part of the skeleton of the Wealden Crocodile transmitted to me by Mr. FOX an extent of three inches of the hinder part of the bony palate is preserved (Pl. 60, fig. 25). In this extent four vacuities are more or less completely shown; they are in two pairs. Of the medial pair (Pl. 60, fig. 25, *s, s*) the left is entire, and the right lacks but a small part of its antero-external border; of the lateral pair (ib., *y, y*) the left wants a part of its antero-external border; but of the right, only a small part of the inner and hinder border is preserved.

The left pterygoid (24) is entire in its relations to the above vacuities, only the postero-lateral branch (answering to *a*, figs. 6 and 7) being broken off. The external branch (figs. 25, 6, 7, *c*), extends as usual, outward and forward to articulate with the ectopterygoid (ib., ib., 25); this abuts by its outer end against the hinder end of the maxillary (ib., ib., 21) and the contiguous part of the malar (ib., ib., 26), the fore part of the pterygoid (24) bounding with the ectopterygoid the hinder half of the pterygo-maxillary vacuity (*y*). The fore part of the pterygoid, continued along the inner border of that vacuity, articulates with the palatine (20), which, with the maxillary (21), completes the fore part of the boundary of *y*. We have thus the homologue of the 'great palatal opening' of CUVIER,[1] and of the 'posterior palatal opening' of EUDES-DESLONGCHAMPS in the *Teleosaurus cadomensis*,[2] which answers to the vacuity *y* in the *Lacertians*, figs. 6 and 7, Pl. 60.

The medial pair of openings (Pl. 60, fig. 25, *s, s*), bounded externally by the palatines and pterygoids, and internally, as it seems, by medial processes of the same bones, answer to the 'fosse ptérygoidienne' (VI) of EUDES-DESLONGCHAMPS in *Teleosaurus temporalis*,[3] and to the 'fosse nasale postérieure' of CUVIER in the *Teleosaurus cadomensis*.[4] But in *Hylæochampsa* this pterygoid fossa, or posterior nostril, is divided by so strong a longitudinal bony bar that the pair of vacuities might be taken at first sight to answer to the 'grands trous palatins' in the *Crocodilus rhombifer*.[5]

[1] 'Ossemen's Fossiles,' tom. cit., p. 133, pl. vii, fig. 4, *r*.

[2] 'Notes Paléontologiques,' p. 139, pl. xi, fig. 3, VII.

[3] Ib., ib., pl. xii, fig. 10, VII.

[4] Tom. cit., p. 133, pl. vii, fig. 4.

[5] Marked *h* in fig. 2 of plate iii of the 'Ossemens Fossiles,' tom. cit., and marked *y* in 'Anat. of Vertebrates,' tom. cit., p. 157, fig. 98, c.

Such a determination is, however, incompatible with the coexistence of the vacuities (*y*, *y*) in *Hylæochampsa* and the concomitant recession of the maxillaries (21) from the outer boundaries of the openings (*s*, *s*, Pl. 60, fig. 25).

We have thus another and most remarkable modification of the bony palate to add to those which have led that acute observer EUGENE EUDES-DESLONGCHAMPS to remark, in reference to the extinct *Crocodilia* of the Caen Oolite and other Mesozoic localities, "chaque espèce présente des modifications particulières."[1]

But although it may be admitted that the pair of medial openings (fig. 25, *s*, *s*) answer to the single medial opening (CUV., t. c., Pl. VII, fig. 4, *s*) in *Teleosaurus*, it does not absolutely follow that they served in *Hylæochampsa* the office of palato-nares. It might be contended that the small single orifice at the mid-line of the extreme hind border of the bony palate (ib., *e*) fulfilled that function, as the similarly sized and situated orifice performs in recent *Crocodilia*. The still smaller orifice (fig. 23, *v*) placed at the hind surface of the skull might in that case be homologized with the median Eustachian outlet,[2] and not with the vascular foramen,[3] in *Crocodilus*.

It should, however, be borne in mind that the true hinder nostril in procœlian Crocodiles is divided by a pterygoid partition; although CUVIER makes the absence of this division, or inconspicuousness of the septum, a character of the skull of procœlian Gavials.[4] *Hylæochampsa* may show this partition in an exaggerated degree, and the orifices *s*, *s*, and not the orifice *e*, would be the hinder nostril.

Whatever alternative may commend itself to competent Palæontologists, the palatal characters which distinguish *Hylæochampsa* from all other known Reptiles, recent or fossil, are unaffected.

I have had no opportunity of studying the palatal characters in *Goniopholis*, *Suchosaurus*, or any other Wealden Crocodile than the subject of the present Monograph.

[1] Op. cit., p. 147.

[2] "On the Communications between the Tympanum and Palate in the *Crocodilia*," *ut supra*, pl. xl, fig. 1, *e*.

[3] Ib., ib., *v*.

[4] "La cloison qui divise les narines ne se montre pas à leur ouverture postérieure." 'Oss. Foss.,' tom. cit., p. 106.

ORDER *PTEROSAURIA.*

MESOZOIC PTERODACTYLES.

HAVING in previous Sections on extinct volant Reptiles defined species (*e. g. Pterodactylus compressirostris, Pter. Cuvieri*, &c., Pls. 1—11, pp. 234—393) from the Upper Chalk, and others (*e. g. Pterodactylus macronyx*, Pls. 15—17, pp. 463—502) from the Lower Lias, I propose, here, to add a brief account of evidences of *Pterosauria* which have reached me from intervening formations of the Mesozoic period.

§ 1. PTEROSAURIA FROM THE 'GAULT' (*Pterosauria*, Pl. 19, figs. 5 and 6).

I commence with one from the deposit called 'Gault,' at Folkestone, which is intermediate in age between the Upper and Lower Greensands, from the former of which Pterosaurian remains, remarkable for their great size (*Pterodactylus Sedgwickii, e. g.*), have been described and figured (p. 380, Pl. 7). Examples of the winged order of Reptiles from the present formation have hitherto been very scanty. The first that has been submitted to my examination is the subject of the following description, and represents the undernamed species.

A.—*Pterodactylus Daviesii*, Owen.

Symphysis Mandibulæ, and Teeth (*Pterosauria*, Plate 19, figs. 5 and 6).

That this fossil, which is figured of the natural size from the lateral (fig. 5) and oral (fig. 6) surfaces, is the fore part of the symphysis of a lower jaw, and not that part of the palate of the upper jaw, is shown by the medial groove in place of the medial ridge on the surface of the bone which was next the mouth, which surface is here on the upper

part of the bone and may have served to lodge and facilitate the movements of a cylindrical protrusile tongue. The character of the palatal surface of the upper jaw is exemplified in *Pterodactylus Cuvieri* (*Pter.*, Pl. 3, fig. 4); in *Pterodactylus compressirostris* (ib., ib., fig. 10); in *Pterodactylus Sedgwickii* (*Pter.*, Pl. 7, fig. 1 *b*); and in *Pterodactylus clavirostris* (Pl. I, fig. 4, of the present section). The grooved character of the oral surface of the mandibular symphysis is shown in *Pterodactylus Sedgwickii* (*Pter.*, Pl. 7, fig. 2 *b*).

The angle of convergence of the two rami of the lower jaw to the symphysis in *Pterodactylus sagittirostris* (*Pter.*, Pl. 18, fig. 8) renders it improbable that the sides of that symphysis would run parallel for the extent shown in ib., Pl. 19, fig. 6, or that the symphysis would terminate so obtusely. Moreover, the five pairs of sockets, with bases of teeth, in the fossil representing *Pterodactylus Daviesii,* indicate teeth of smaller size and closer disposition than in the mandible of *Pterodactylus sagittirostris.* The foremost pair of sockets (ib., figs. 5 and 6, *a*) are less elliptical than the rest. The base of the tooth retained gives an almost circular section; the outlet of the socket is directed more obliquely outward than those of the others, and the crowns of the teeth were, probably, more divaricated in this foremost pair. The sections of the bases of the teeth in the sockets *b*—*e* give a fuller ellipse than the outlet of the sockets themselves. The outer surface of the bone is smooth and even, the upward curve from the under margin of the symphysis is gradual, as shown in fig. 5.

This specimen was discovered in the 'Gault' at Folkestone, by Mr. William Davies, of the British Museum, to whom, in acknowledging much useful assistance, I have pleasure in dedicating the species of Pterodactyle indicated by the present fossil.

§ 2. Pterosauria from the Wealden.

A.—*Pterodactylus sagittirostris,* Owen (*Pterosauria,* Plate 18, figs. 1—8).

The type of Cuvier's genus *Pterodactylus* is the species which he calls *longirostris.* The chief generic character is the extreme length of the fourth digit of the fore-limb.[1]

The *Pterodactylus longirostris,* Cuv., is characterised, as the term implies, by long, slender, tapering jaws, armed along their anterior half by numerous long, slender, pointed, separated, and pretty equally distant teeth.

In a general way the portions of mandible about to be described repeat these characters. The mandibular teeth appear to have been about the same in number. Nineteen are reckoned by Cuvier to have occupied the dentigerous part of each mandi-

[1] "Un genre de Sauriens, caracterisé par l'excessif allongement du quatrième doigt de devant, auquel nous avons donné le nom de Pterodactyle."—'Ossemens Fossiles,' tom. v, pt. ii, 4to, 1824, p. 358.

bular ramus in the type-species;[1] and about as many appear to have armed the same part as *Pterodactylus sagittirostris.*

There is as little trace of condyloid or coronoid processes in the present Wealden Pterodactyle as in the Oolitic longirostral species.[2]

The great and rapid addition to the number of extinct flying Reptiles having the characters of Cuvier's genus *Pterodactylus* has led to its subdivision into several groups or subgenera.

If length of tail with number of caudal vertebræ be accepted as a generic character, those that have that appendage long, and supported by more than thirteen vertebræ, must go to a different group from that including the *Pter. longirostris.*[3]

It is plain that *Pter. sagittirostris* has not the generic dental characters of *Dimorphodon.* It is probable that the symphysial modification which supports the generic name *Ramphorhynchus* was not present.

If the skull of the long- and sharp-jawed Wealden species, or of that from the Upper Chalk which I have described under the name of *compressirostris,* should ultimately be found to offer marked differences in the forms, sizes, and proportions of the narial, orbital, and intermediate vacuities, from those figured by Cuvier in pl. xxiii (op. cit.), it may be deemed requisite to refer them to a distinct pterosaurian group. At present it appears to be convenient to place the sagittirostral and compressirostral with the typal species in the Cuvierian genus *Pterodactylus.*

The most striking characteristic difference from that species is the vastly superior size of the seemingly allied Flying Dragons from the British Chalk and Wealden.

In the restoration of the skull of *Pterodactylus compressirostris* (pp. 234—252, Pls. 1—5) I ventured to assign to the mandible a length of 14 inches 9 lines (*Pter.*, Pl. 1, fig. 5). This species was represented by two portions of the upper jaw from the Middle Chalk of Kent, the longest portion being 4 inches in length. Of the nearly allied species, represented by three portions of the lower jaw, discovered by Samuel H. Beckles, Esq., F.R.S., F.G.S., in the Hastings series of the Wealden Formation, west of St. Leonard's-on-Sea, the restoration figured of half the natural size in Pl. 18, fig. 8, gives a mandible of between 14 and 15 inches in length, and this on the most moderate estimate of the length of the symphysis. In a sketch of a restoration of the jaw, sent to me with the fossils by Mr. Beckles, the length of the symphysis, which he assigns on the basis or analogy of that in Collins's or Cuvier's *Pterodactylus longirostris,* gives a total length of 18 inches to the mandible.

The parts obtained by Mr. Beckles are of one and the same lower jaw; and, as an extent of above 2 inches of both rami are maintained by a portion of matrix (ib. ib.,

[1] Cuvier, tom. cit., p. 364.

[2] Ib., ib.

[3] In which Cuvier describes the tail as "très-courte, très-grèle, et l'on n'y compte que douze ou treize vertèbres."—Tom. cit., p. 368.

fig. 8, *m*) in their natural relative position, the angle of convergence is shown; and this affords a ground for estimating the length of each ramus from the articular surface to the hind part or border of the symphysis at 13 inches, the extent beyond remaining conjectural.

The specimen includes a portion of the left ramus, 9 inches 8 lines in length (of which the anterior 7 inches are given in Pl. 18, fig. 1), and two portions of the right ramus, of which the dentary part measures 5 inches (ib., fig. 2) in length, the articular part 2 inches (ib., fig. 5).

The portion of the left ramus includes the dentary element (ib., fig. 1, and fig. 4, 32) with the anterior part of the splenial element (fig. 4, 31). The dentary includes ten of the hinder sockets (ib., fig. 1, 1, 2, 3, 4, 5), of which the five foremost (ib., 6, 7, 8, 9, 10) retain more or less of their teeth. As the number of these which may have been present in the fore part of the jaw is unknown, I count those which are preserved from the hind end of the series forwards. Prolonging the alveolar border according to a moderate estimate of the symphysis, and supposing the teeth to maintain the same intervals, about eighteen may be assigned to each ramus.

The border of the hindmost socket (fig. 1, 1) is not prominent as in the rest, and there is room for doubt whether the oval vacuity which indicates the hindmost tooth really contained one. There is none, however, with regard to the next socket (ib., 2), for this, like the antecedent ones, rises at its outlet above the level of the surrounding part of the bone. It projects from the outer part of the thick, transversely convex, upper border of the dentary, and the course of the cavity shows that the tooth must have inclined somewhat outward as well as forward from the perpendicular. The long diameter of the outlet is in the axis of the jaw, and is $1\frac{1}{2}$ lines (3 m.m.). The short or transverse diameter is 1 line (2 m.m.). The interval between this socket and the one marked 3 is 5 lines (10 m.m.).

The prominent outlet of the socket 3 gives 5 m.m. in long diameter and 3 m.m. in short diameter; these dimensions with that of the interval are repeated to the socket 6, which retains its tooth. The exserted crown of this is 5 lines (10 m.m.) in length; it is conical, acute, gently curved, with the convexity outward and forward.

The apex of the next tooth in advance is broken off, but the basal half is better cleared out of the matrix, giving an antero-posterior breadth of its issue from the socket of 5 m.m.

The teeth in the sockets 8 and 9 are better preserved, and show well the characters of the mandibular ones in the present species.

As in *Pterodactylus longirostris*, the teeth of *Pter. sagittirostris* are subsimilar, divided by nearly equal intervals, these being somewhat wider than in *Pter. longirostris*,[1] relatively shorter than in *Pter. crassirostris*,[2] and more resembling in disposition the indica-

[1] *Pterosauria*, Pl. 1, fig. 1.

[2] Ib., ib., figs. 2 and 3.

tions given by the sockets in the portion of upper jaw of the Cretaceous *Pterodactylus compressirostris.*

The dentary bone supporting the above-numbered teeth is slender and subcompressed; its depth is given in figs. 1, 2, and 4 (nat. size); its thickness is shown in fig. 3.

This is the same at both upper and lower borders, which are similarly rounded off; it is less half way down, owing to the concavity, vertically, of the inner surface of the ramus (ib., fig. 4). The outer surface (fig. 1) is nearly flat; it is traversed lengthwise by a linear impression, which is 5 m.m. below the upper border at the hind end of the proportion of the ramus figured in fig. 1, and is 7 to 8 m.m. below the outlets of the sockets of the teeth 7—9. This linear impression does not indicate a suture.

The ramus slightly increases in thickness, with a gain of convexity externally and a deeper concavity internally (both being in the vertical direction), at the fractured end (ib., fig. 1, 32) nearest the symphysis. At the opposite end the angular element (ib., fig. 4, 30) forms the inwardly prominent lower border; the line between which and the thin flat splenial forms (ib., ib., 31) is clearly sutural.

The portion of the right dentary preserved (Pl. II, figs. 2, 3) answers to that containing the sockets of the teeth numbered 2—9 in fig. 1. There is the same obscurity or lack of demonstration of a socket or tooth behind the socket 2.

The bases of the teeth are preserved in the sockets (numbered 2—6), and partly project from the sockets 2 and 3, but the sockets 7, 8, 9, are vacant.

The articular portion of the right ramus (figs. 5, 6, 7) lacks the prominent, backwardly directed, end of the subangular (30).

The articular concavity (fig. 6, *a*) is transversely extended, chiefly by the production of its inner wall (ib., *b*); its upper boundary is sinuous by a backward production of its mid part; the upper surface in advance of the cavity is smooth and gently convex across; it narrows to the ordinary thickness of the ramus about an inch and a half in advance of the articulation. In this extent it shows no trace of a coronoid rising. The inner surface is impressed with a deep longitudinal cavity (ib., fig. 7, *c*).

According to the usual proportions of the upper and lower jaws of Pterodactyles, the premaxillary of the present species must have been twice, or nearly twice, the depth or vertical diameter of the portion of that bone of *Pterodactylus compressirostris* (figured in *Pter.*, Pl. 3, fig. 8). Both upper and lower jaws of *Pterodactylus sagittirostris* must have been broader, less compressed, than in the Cretaceous *Pter. compressirostris.*

The value of a symphysis mandibuli, with its natural anterior termination, like that of the Gault species (*Pterodactylus Daviesii*), is its demonstration of a character determinative of the genus of Pterosaurian. Were it produced into a slender-pointed edentulous style, or 'rostrum,' it would lead to a reference of the species to Von Meyer's genus *Rhamphorhynchus* and Family '*Subulirostres.*'[1] The opposite extreme is shown by the thick

[1] 'Palæontographica,' Heft i, 4to, 1846.

obtusely terminated snout, as if it had been cut short, giving the character of the Pterosaurian family *Truncirostres*.[1] The species of this family which have the foremost pair of teeth projecting forward in the upper jaw from the truncate surface at a higher level than the alveolar border form the genus *Coloborhynchus*.[2]

B.—*Coloborhynchus clavirostris*, Owen (*Pterosauria*, Plate 19, figs. 1—4).

In two species of these large Pterodactyles from the Cretaceous series, viz. *Coloborhynchus Cuvieri*, from the Middle Chalk of Kent,[3] and *Coloborhynchus Sedgwickii*,[4] from the Upper Greensand of Cambridge, the anterior pair of teeth of the upper jaw project, as in the present species, from the fore part or end of the premaxillary, and are directed forward with a slight downward curve.

In a still larger species (*Criorhynchus simus*[5]), from the Upper Greensand of Cambridge, the foremost pair of teeth project from the under surface of the fore end of the premaxillary, and are directed downward like the following teeth. The fore end of the premaxillary was fortunately entire, showing a flattened or feebly concave tract corresponding to the part bored by the anterior alveoli in *Coloborhynchus*. Some reserve may be prudently entertained as to whether a pair of teeth so anomalously located as in *Coloborhynchus* might not be shed without replacement by successors; and the genus *Criorhynchus* is to be accepted with this reserve, which future discoveries may dissipate. The manifestation by a 'truncirostral' Pterodactyle of the Wealden, and by another from the 'Greensand,' of the produced and unopposed pair of teeth from the front surface of the muzzle, have dissipated the doubts as to its accidental and individual character which legitimately attached to the first specimen, from the Chalk, in which it was observed.

Coloborhynchus clavirostris is, at present, represented by the fore part of the upper jaw of a Pterodactyle (*Pter.*, Pl. 19, figs. 1—4) from the Wealden, of equal size with *Criorhynchus simus*, from the Upper Greensand, but in which the small anterior pair of premaxillary teeth project from the front surface of the bone, and at a greater elevation above the palate and the sockets of the second pair, than in *Coloborhynchus Cuvieri* or *Colob. Sedgwickii.*

The flattened fore part of the premaxillary (ib., fig. 2) is broader and of less height in *Coloborhynchus clavirostris* before the narrow upper surface (*g*) begins to slope backward to the upper contour of the cranium. The anterior median depression (*h*) is shorter

1 Mihi (*Truncus*, cut short).

2 κολοβὸς, stunted; ῥύγχος, snout.

3 *Pterosauria*, Pl. 3, figs. 1—7.

4 Ib., Pl. 7, figs. 1, *a—d*.

5 *Pterosauria*, Pl. 11, figs. 1—5.

vertically and deeper in *Colob. clavirostris*, where it is below the alveoli of the teeth (*a, a*). The convexities (*i, i*) on each side of this depression are the fore parts of the sockets of the second pair of teeth, not of the first pair, as in *Criorhynchus simus* (*Pter.*, Pl. 11, fig. 3, *a*). The sides of the fore part of the premaxillary in *Coloborhynchus clavirostris* converge, with a slight vertical concavity, to the narrow but obtuse upper border of the skull; the same sides also converge as they recede in a slighter degree, but so that the breadth of the upper jaw behind the sixth pairs of teeth (ib., Pl. 19, figs. 1 and 4, *f, f*) is less than two thirds the breadth behind the second pair of teeth (ib. ib., *b, b*, fig. 4), whence the name *clavirostris* ('club-snout') proposed for the present formidable species of Wealden Pterodactyle.

The fore part of the bony palate, between the teeth of the second pair (ib., ib., fig. 4, *b, b*), is transversely quadrate and flat (ib. ib., fig. 4, *k*). Behind this tract the mid third only of the palate retains its level, the two side thirds subsiding (as it seems when looked down upon) into shallow channels, which expand and are continued into the slope rising to the sockets of the fifth (*e*) and sixth (*f*) teeth, leaving the prominent narrow mid tract to represent, as it were, the bony palate; this part has projected below the level shown between the fourth pair of teeth, behind which the thin compact wall is broken away, exposing the widely cellular structure. A similar abrasion affects the upper border of the skull (beyond *i*, fig. 1, Pl. 19).

The first or anterior pair of teeth (ib., *a, a*) bears the same relations of size to the second (*b*) and third (*c*) pairs as in *Criorhynchus simus*, and may be homologous with the first pair in that species (*Pter.*, Pl. 11, fig. 1, *a*) though differing so much in position and direction. In the present specimen of *Coloborhynchus clavirostris* the crown of the first, as of the second, tooth is broken off at the outlet of the socket. The shape of this outlet is a full ellipse (Pl. 19, fig. 2, *a, a*); the long diameter, of 8 m.m., is vertical; the short diameter, of $6\frac{1}{2}$ m.m., is transverse. The size and shape of the five following teeth are shown in fig. 1; for, as is common in Pterodactyles, the sockets open obliquely upon the outer part of the alveolar border, and in the present species with a nearer approach to verticality than is usual (compare Pl. 19, fig. 1, with Pl. 11, fig. 1.

The present unique evidence of one of the most extraordinary of the extinct order of volant *Reptilia* was discovered by S. H. Beckles, Esq., F.R.S., in the Hastings Series of the Wealden.

The humerus of the *Pterodactylus sylvestris*, Ow.,[1] from the Tilgate Wealden, though larger than those next to be described, must have belonged to a smaller kind of Pterosaur than that represented by Mr. Beckles's fossil.

[1] 'Quarterly Journal of the Geological Society of London,' No. 6, 1846, p. 99, figs. 5, 6, 7.

§ 3. Pterosauria of the Kimmeridge Clay.

A.—*Pterodactylus Manselii*, Owen (*Pterosauria*, Pl. 19, figs. 10, 11, 12, 20, 21).

Figures 10 and 11 of Pl. 19 show front (thenal) and back (anconal) views of a mutilated proximal end of the left humerus of this rather small species of Pterodactyle. The reniform articular surface of the head of the humerus (fig. 12, *a*) is somewhat less extended transversely in proportion to its breadth than in a similarly sized species from the Lias (*Pterodactylus Marderi*, ib., fig. 9); its anconal convex border has a bolder curve. There is no indication of a pneumatic orifice on this surface, as in Birds. The pectoral process (*b*, figs. 10 and 11) stand out more abruptly from a less extended base (compare with *b*, figs. 7 and 8, Pl. 19).

The proximal end of the first phalanx of the fourth or wing-finger, which is the subject of figs. 20, 21, 21^x, corresponds in size with the portions of humerus above described, near which they were discovered. The olecranoid process (ib., fig. 21, *c*) led observers of the first discovered specimens of this eminently pterosaurian bone to regard it as an ulna. Upon this process is extended part of both the outer and inner concave articular surfaces, so placed as to resemble the two divisions of the 'greater sigmoid cavity' in the human ulna, the curve and depth of which surfaces is thus augmented, and therewith the security of the flexible joint on which the chief movements of the bat-like wing take place. The outer surface, shown in fig. 20, is of less extent, in long diameter, than the inner articulation (ib., fig. 21, *a*); a larger proportion of it is supported by the olecranoid process; and it is better defined along the margin next the longer concavity (*a*). Nevertheless, the smoothness of the surface of the ridge, dividing the concave articulations, suggests that they combined to form a single synovial hinge-joint or 'ginglymus,' limiting the movements of the bones so articulated to one plane, and combining freedom and extent of motion in that plane with great strength of joint. The summit of the olecranoid process in the present specimen shows a rough flattened surface, not a fracture, suggestive of the contact of a sesamoid, probably lodged in the tendon inserted into the phalanx (ib., fig. 21^x).

B.—*Pterodactylus Pleydellii*, Owen (*Pterosauria*, Plate 19, figs. 15, 16, 22, 23, 23^x).

The portion of the fossil skeleton of the small species of Kimmeridgian Pterodactyle here figured is the distal half of the left humerus. It shows the generic obliquity and superiority of size of the articular convexity for the head of the radius (ib., fig. 15, *a*,); that for the ulna has suffered fracture, and part of it is lost with the ulnar tuberous ridge;

but sufficient remains to show its hemispheroid form, and the mere chink dividing it from the radial condyle instead of the groove which is here seen in Birds. The flexor (?) ridge, leading to the broken tuberosity, extends more forward than in *Pterodactylus Duncani* (ib., fig. 13), and contributes to a deeper concavity above the condyles on the thenal aspect of the distal expansion of the humerus. The transverse ridge behind the condyles is confluent therewith at its extremities, the defining groove not being developed (ib. ib., 16'). The broad shallow canal for the 'triceps' tendon marks the anconal surface of this expansion (ib., fig. 16).

To the same species of *Pterodactyle* may probably belong the proximal end of the smaller example of the first phalanx of the fourth or wing-finger, of which I have given two views in Plate 19, figs. 22, 23, and 23^x, to contrast with those of the same bone and part of *Pterodactylus Manselii*. The olecranoid process in *Pterodactylus Pleydellii* is relatively longer and more incurved; its apex is not truncate; it is more compressed; has a smaller and lower posterior tuberosity, and a smaller basal tuberosity. The longer concave articulation is similarly extended upon the anterior angle. From the tuberosity at the corresponding or lower end of the shorter concavity a ridge is continued down the bone, giving a triedral form to the shaft as far as it is preserved in this and the previously described specimen (figs. 20, 21). The bony wall of the shaft is thin and compact, the air-cavity large, and in one specimen occupied by crystallised calcite. The two narrower sides are concave or flat transversely; the broader side is gently convex; it shows, in both species (figs. 21, 23), a longitudinal linear impression, which may indicate a confluent rudiment of a fifth digit.

To the above-described, well-defined, trochlear or ginglymoid joint were adapted the two obliquely disposed condyles of the distal end of the metacarpal of the fourth or wing-finger.

I have pleasure in contributing this mite of testimony to the unremitting attention to the fossil evidences of Kimmeridgian Vertebrates, discovered from time to time on his estates by John C. Mansel-Pleydell, Esq., F.G.S., of Longthorns, Blandford, and to the wise liberality by which they have uniformly been deposited in the National Collection, where inferences and conclusions from their study can be tested by Palæontologists.

C.—*Pterodactylus*, sp. incert.

Two specimens of the carpal bone, provisionally referred in a preceding Section to a Pterosaurian '*unciforme*,' are figured in Plate 19, figs. 24—27. They were both obtained from the "Kimmeridge Clay," at Weymouth, Dorsetshire.

The distal surface of the smaller specimen is given in figure 24; they show the larger concavity (*a*), and the smaller one (*b*), adapted to the two proximal condyles of the

metacarpal of the wing-finger. The thenal border of the bone is the thinnest, and is produced at each end into a short process; the anconal border of the bone is thicker, especially where it supports the smaller and outer articular metacarpal concavity.

The proximal surface (ib., fig. 25) is also divided into two principal articulations, but the larger one (*c*) is subdivided into a concave and a flattened facet. The smaller concave surface (*d*) is next the outer and thickest end of the bone.

The subject of figs. 26 and 27 is the homologous bone, and from the forelimb of the same side, but it shows modifications that plainly bespeak its having come from a distinct species of Pterodactyle. The outer subhemispheric concavity of the proximal surface (ib., fig. 27 *d*) is relatively larger, as is likewise the flat facet at the inner part of the larger surface (*c*). The two condylar concavities (*a* and *b*) on the distal facet are more equal than in the larger unciforme.

Both bones exemplify the definite, well-marked, or finished character of the articular surfaces which characterise the bones, especially those of the wing, of the volant Reptile.

I would still be understood to be guided by considerations, not beyond probability, in referring this well-marked bone to the distal row of the carpal series; for I have not yet had the opportunity of studying a Pterosaurian carpus or tarsus in so well-preserved and undisturbed a condition as would enable me, with certainty, to determine the homologies of its constituent bones.

§ 4. Pterosauria of the Great Oolite.

A.—*Pterodactylus Kiddii*, Owen (*Pterosauria*, Plate 19, fig. 17).

The first phalanx of the wing-finger (fig. 17), referable to this species is somewhat stouter, but about one eighth shorter, than that bone in the *Pterodactylus suevicus*, Quenstedt,[1] from the Lithographic Slate of Wirtemberg. It indicates a species with a more powerful, though, perhaps, less elongate, wing. The groove for the flexor tendon of the fourth digit, bounded by the prominent thenal extensions of the two articular grooves, is well marked. The extensor process (ib., *c*) has a relatively longer basis than in the Kimmeridge specimens. A rough groove or linear depression beginning about an inch beyond the proximal articulation, and extending as far down the fore or thenal surface of the shaft of the bone, indicates the extensive attachment or insertion of that tendon. The shaft is subtriedral, the anconal side being the broadest; it becomes flattened towards the distal end, which expands unequally towards the ulnar side, and

[1] "Ueber *Pterodactylus suevicus*," 4to, Tübingen, 1855.

affords an oblong, moderately developed, concavo-convex surface for the second phalanx of the wing-finger.

This bone, from the Stonesfield Oolite, is slightly crushed.

B.—*Pterodactylus Duncani*, Owen (ib., Plate 19, fig. 18).

The first phalanx of the wing-finger, referred to the above species, is of the left wing, and is imbedded with the anconal surface exposed in a slab of Stonesfield Slate.

It is from a larger Pterodactyle than the preceding. The extensor process is thicker but springs from a less extended base, relatively to the length of the bone.

C.—*Pterodactylus Aclandi*, Owen (ib., Plate 19, fig. 19).

This species is represented by a still larger specimen of the characteristic wing-bone (fig. 19) in Pterosauria. The olecranoid process ($_c$) is shorter in proportion to the breadth and thickness of the proximal end, and the free termination of the prócess is more definitely marked by a smooth and shallow groove, over which it seems that the tendon of the "extensor alæ" may have glided before its insertion into the strong rough process (^{e}).

The second phalanx of the wing-finger (Plate 19, fig. 28) may have belonged to a Pterodactyle of the same species or size as the proximal phalanx of the *Pterodactylus Kiddii*. On this hypothesis its proportion of length would resemble that in the *Pterodactylus* (*Dimorphodon*) *macronyx* (*Pterosauria*, Plate 17). The distal end of the present "Stonesfield" bone becomes triedral by the rise of a ridge from the thenal aspect, extending longitudinally, and enlarging, to near the outer end of the distal oblong articular surface; this is more convex transversely than is the proximal surface. The longitudinal ridge in question afforded insertion to a strong flexor tendon.

§ 5. Pterosauria from the Lias.

I have not yet received any evidence of a Pterosaurian from the "Alum Shales" of Whitby, or any other member of the Upper Lias of our North-Eastern Coast, which represents, by the sum of its palæontological evidence, the "Posidonomyen-Schiefer" of Bavaria. There, however, in the locality of Banz, have been discovered instructive

remains of a Pterosaurian, which Professor Quensted refers to my Lower-Liassic genus under the name of *Dimorphodon Banthensis*.

The specimen about to be described, from the Lower Lias of Lyme Regis, is insufficient to give subgeneric characters, and is provisionally registered under the wider generic name.

A.—*Pterodactylus Marderi*, Owen (*Pterosauria*, Plate 19, figs. 7, 8, 9).

Of this species is here figured the upper or proximal half of the right humerus (figs. 7 and 8). The head or articular surface (fig. 9) is a narrow, bent, or reniform convexity, with the concave margin toward the thenal side of the bone (fig. 7). The inner and more obtuse end of the articulation, with the tuberosity of that side, is broken away; the outer, narrower, and, in this species, pointed end is lost upon the ridge or upper border of the "pectoral process" (*b*). The expanded part of the shaft, beyond the articulation, is concave transversely on the thenal aspect (fig. 7), convex on the opposite or anconal side (fig. 8), which shows, as usual, no trace of the fossa and foramen characterising that part of the humerus in Birds of flight. The antero-posterior thickness of this part of the bone is less than that of the contracted cylindrical part of the shaft lower down, the section of which is circular.

This humerus, besides being smaller than that of *Dimorphodon macronyx*,[1] has a more straight and slender shaft, which in transverse section is more nearly cylindrical.

B.—*Dimorphodon macronyx*, Owen (*Pterosauria*, Plate 19, figs. 13, 14).

The other Pterosaurian fossil, obtained by Mr. Marder, from the same formation and locality, might well, by its superior size, and more ellipsoid section of the shaft, have formed part of the first long-bone of the wing of the species restored in *Pter.*, Plate 17.

The articular surfaces of the humerus in both specimens of this Pterosaurian figured (ib., Plates 15, 16, 53, 53[1]) were too much crushed and mutilated for profitable description. The present specimen shows instructively the distal articulation.

The surface for the radius presents one uniform convexity, *a*, oblong in shape, and obliquely disposed, extending from the lower part of the radial ridge (*c*), upward, forward, and ulnad; it is almost wholly developed from the thenal aspect (fig. 13), only the lower border of the convexity being visible from the anconal side (at *a*, fig. 14). It is longer and more prominent than the ulnar convexity or condyle. This (ib., *b*) is subhemispherical;

[1] 'Monograph of Liassic Pterosauria,' Pal. vol. for year 1869, pl. xviii, figs. 53, 53 *a*.

its diameter equals the shorter diameter of the radial condyle. The intercondylar fissure is a mere cleft; and tuberous ridges, extending from the condyles, augment the breadth of the distal end of the humerus. The outer or radial one (*c*) is produced forward, bounding there, and in part forming the anterior concavity. The inner or ulnar ridge (*d*) is more distally placed, projecting to a lower level than the condyle (*b*); it is continued upwards with a convex curve, but is not produced forward like the radial ridge.

Both ridges are connected by a narrower one, extending transversely behind the two condyles, from which it is divided by a fossa (fig. *d*, *c*). There is a broad and shallow depression on the back part of the distal end of the humerus for a large "triceps" tendon: there is no anconal depression.

In my description of the articular end of a long-bone of a Pterosaur (figured in *Pter.*, Pl. 10, figs. 1, 2, 3), I remarked that, "guided by considerations of size, the fragment might form the opposite end of the bone, indicated by the articular ends (Pl. 9, figs. 7 and 8), which were referred to the head of the humerus. But I proceeded to remark, 'I am not acquainted with the precise configuration of the distal end of the humerus in any Pterodactyle. From general analogy, however, one should scarcely be prepared to find so feeble an indication of divisions into condyles, an absence of a general convexity, and a presence of a well-defined concavity in one condyle, and as well defined a flattened or feebly concave facet in the other condyle, of the distal end of a humerus." The demonstration of the true characters of this end of the humerus, given in Plate 19, figs. 13, 14, and *d*, *c*, have justified the refusal to regard the articular end of the bone of the large Cretaceous Pterosaur as part of the humerus.

There is no part of the skeleton of the Bird that more resembles the answerable bone in a Pterosaur than the humerus. But the following, with other differences pointed out in previous Sections of this work, are well marked and, as far as my observation goes, constant.

The pectoral process from the radial side of the proximal expansion of the humerus is relatively longer from base to apex, with a broader, more truncate, or less pointed termination in the flying Reptile: it usually forms a low angle in the Bird.

At the distal end of the humerus of the Bird the oblong radial condyle is usually more pointed anteriorly; the ulnar one is more extended transversely, and the intercondylar cleft is widened to a groove. The outer and inner ridges are not connected by a post-condylar transverse ridge. The olecranial surface is more depressed, and the tricipital tendinal grooves are better marked; but the transverse expansion of the distal end is less in proportion to the breadth of the shaft of the humerus in the Bird than in the Pterosaur.

Other differences in the Pterosaurian humerus, notwithstanding its adaptive development to flight, showing departure from the avian, and approach to the crocodilian, type have been previously pointed out.

The largest vertebra in a swan, an albatross, a condor, or a lammergeyer, scarcely

equals the largest known vertebra of an unquestionable Pterodactyle (comp. *Pter.*, Pl. 8, figs. 7, 11, and *Pter.*, Pl. 12, figs. 1 and 2). But these pterosaurian vertebræ are from the region of the neck, and served to sustain a head which, from the proportions of that in *Dimorphodon macronyx* (*Pter.*, Pl. 17), and most probably also in *Criorhynchus simus* (*Pter.*, Pl. 11, figs. 1—3) and *Coloborhynchus clavirostris* (*Pter.*, Pl. 19, figs. 1—4), was considerably larger in relation to the trunk and wings than in the largest examples of birds capable of flight. We may with reason, therefore, assume that the total magnitude or weight capable of being raised and sustained in air was not greater in the cold-blooded, naked, volant reptile than in the warm-blooded, feathered bird. The instruments of flight were, however, relatively longer in *Pterosauria*. In illustration of this proposition I subjoin admeasurements of the chief parts of the skeleton in the best-restored specimen of a flying dragon, viz. that of *Dimorphodon macronyx*.

	ft.	in.	lines.
Length of head . . .	0	8	0
,, neck . . .	0	3	6
,, trunk . . .	0	6	8
,, tail . . .	1	9	0
,, femur . . .	0	3	6
,, tibia . . .	0	5	0
,, foot . . .	0	3	6
,, humerus . . .	0	3	7
,, antibrachium . . .	0	4	3
,, fourth or wing-finger . .	1	5	10
,, bones of a wing, from head of humerus to end of wing-finger . .	2	3	6
Breadth of trunk between articular ends of right and left scapulæ . . .	0	3	9
Span of outstretched wings, including breadth of trunk	4	10	0

Now, the largest neck-vertebra of *Criorhynchus simus* (*Pter.*, Pl. 12, fig. 1) is rather more than two such vertebræ in *Dimorphodon macronyx*. Other things being equal, therefore, we may assign to *Criorhynchus simus* a span of outstretched wing of nine or ten feet.

Birds, like the cassowary, ostrich, and moa, which have attained a bulk superior to that of the albatross, obey the law of gravitation, and lose the faculty of soaring above the surface of the earth. We may with reason, therefore, conclude that we have in *Criorhynchus simus* and *Coloborhynchus clavirostris* the extremes of magnitude in the volant Reptilia.

ORDER. *DINOSAURIA.*

Genus—BOTHRIOSPONDYLUS.

Species—*Bothriospondylus suffossus*, Owen ('Dinosauria,' Plates 61—63).

THE subjects of the present section might be deemed to have more interest for the Anatomist, by reason of the singular modification of vertebral structure which they exhibit, than for the Palæontologist, as affording evidence of an additional specific or generic form to the already known numerous extinct Saurian Reptiles of the Mesozoic formations.

The vertebra, for example (Pl. 61), which, by the presence of pre-(p) and post-(p') parapophyses with expanded rough syndesmotic articular surfaces, is a sacral one of the Dinosaurian type, presents so singular a degree of depression, or horizontal flattening, of the centrum, as to suggest artificial and posthumous pressure as its cause; and it is true that some of the lumbar or dorsal vertebræ therewith associated show unmistakable marks of such violence. But, as the side view of the present vertebra, ib., fig. 4, shows, at c, c', there is no such evidence of fracture of the peripheral compact layer of the bone with distortion, causing more or less departure from symmetry in the centrum, as accompanies every instance of crushing out of shape in the present series of vertebræ (compare figs. 1 and 4, *e.g.*, with fig. 5, in Pl. 63). There is also evidence of a transitional assumption of the depressed form of centrum, in another sacral one (Pl. 62, figs. 4, 5, 6), which, from having the syndesmosal surface on a single parapophysis (p) on each side, was part of a terminal vertebra of the sacral series.

Four views (Pl. 61, figs. 1—4) are given of the vertebral centrum which appears to correspond with that marked 5 in 'Dinosauria,' Pl. 38. In the sacrum of the *Hylæosaurus* there figured the vertebra No. 5 offers the greatest breadth and flattening of the under surface, which is also notable for the absence of the longitudinal ridges, parial or single, marking the under surface of the succeeding or preceding centrums.

The under surface of the present sacral (Pl. 61, fig. 1) is less accentuated than the Hylæosaurian one compared with it, and the venous canals are relatively smaller than in it: they also issue irregularly, instead of being symmetrically disposed as are the large pair in *Hylæosaurus*. The under surface, as shown in the side view (ib., fig. 4, c), is feebly undulate lengthwise, the concave curves being mainly due to the expansion of the articular ends (ib., fig. 3). The under surface of the centrum is as moderately convex across, becoming flat near the free portions of the side of the centrum (ib., figs. 1, 2, 4, c'), and very slightly concave through the distal expansion of the parapophyses (ib., fig. 1, p p'). But the distinctive peculiarity of the present centrum from the known sacral ones

of other Dinosaurs is the continuation of the free surface, over the side of the centrum (fig. 2, *c'*) between the origins of the parapophyses (*p*, *p'*) into a long, low and deep cavity (ib., figs. 2 and 4, *f*, *f*), overarched by the part of the side of the centrum supporting the neurapophyses (ib., figs. 2 and 4, *np*), which appear to have been confluent therewith, and to have been removed, with the rest of the neural arch, by fracture.

This displacement exposes the floor of the neural canal (ib., fig. 2, *n*), the breadth of which indicates a sacral enlargement of the myelon, and consequent development of the pair of limbs deriving their nerve-supply therefrom. The issue of a large pair of these nerves is indicated by the continuation of the neural surface outward at *o*, *o*, behind the broken bases of the neurapophyses (*np*) which have not extended so near to the end *b*, as to the opposite end, *a*, of the centrum.*

Owing to the abrupt continuation of the lateral surface of the centrum into the depressions, *f*, *f*, characteristic of the present genus of Dinosaur, the free surface of the side of the centrum presents the form of a smoothly rounded, longitudinally concave, ridge (ib., figs. 2 & 4, *c'*). It may be that the approximation of the roof and floor of the lateral fossæ has been increased by pressure. Yet the horizontal surface, *f*, could hardly have been bent from the vertical side-surface of the centrum, *c'*, without some fracture of the compact outer layer of bone; and, further, if the flat form of the centrum had been due to such cause, the seemingly natural undulate configuration of the under surface, with its expansion at the two ends, would not have been unobliterated and unmodified in the degree exhibited by the fossil specimen.

The outward production of the fore part of each side of the centrum (fore parapophysis, *p*) has a longitudinal extent of an inch and a half, a vertical one at the articular surface of seven to eight lines. The surface is rough and slightly concave; it may have contributed less than one half of the vertical extent of the sacro-iliac joint at this part. The fractured or roughened surface above this parapophysis indicates a corresponding diapophysial production of the neural arch for extension of the joint. Longitudinally the pre-parapophysial surface slightly inclines toward the front articular surface, *a*, of the centrum. This surface is flat, very rough, and irregular, indicative of having been broken away from a partial confluence with the opposed surface of a contiguous sacral element; the lower part showing here and there a smoothness as of the original free surface of this end of the centrum. Above this surface large unossified vacuities are shown in the cancellous texture of the bone. The vertical diameter of the articular end of the centrum is one inch three lines; the transverse diameter is three inches six lines. The lower margin is not entire, but has been eroded or worn away for an equable extent of about four lines; along the transverse curve it has not been broken off that end of the centrum.

The post-parapophyses (*p'*) are shorter antero-posteriorly, thicker vertically; and the articular surfaces of this pair converge at a greater angle to the posterior surface, *b*, of the

* Compare the figure of the sacral vertebra of *Iguanodon*, Pl. 12, fig. 4, *o*, *o*, p, 288.

centrum (ib., fig. 3) than in the anterior pair. The upper rough or fractured surface (fig. 3, *n*, *n*) may have coalesced with the fore part of the neural arch of the succeeding sacral vertebra, if such arch, as in other Dinosaurs, has crossed the interval between its own centrum and that of the next sacral. A greater extent of the hinder surface of the present centrum (fig. 3, *c*), at its lower half, shows freedom from anchylosis than on the fore surface.

The Reptile indicated by the portion of the vertebra above described is referable by the characters which such fossil shows to the Dinosaurian group. In the *Crocodilia* the confluent outstanding parts of centrum and neurapophyses, affording attachment to the pelvic arch, are single on each side of the sacral vertebra, and the neural arch retains its normal position in connection with its centrum.*

In *Megalosaurus* the lateral abutments for iliac attachments have diapophysial bases, or spring exclusively from the neural arch.† Pre- and post-parapophyses are indicated in the sacral vertebræ of *Iguanodon* by the slightly produced or outstanding parts of the side of the centrum articulating with the two displaced neural arches (compare figs. 1 and 2 of Pl. 61, with figs. 3 and 4, 'Dinosauria,' Pl. 12). In the sacral vertebra of the *Hylæosaurus*, above referred to, the duplex parapophyses have about the same development as in *Bothriospondylus*.

Not any of these earlier described *Dinosauria* have the flattened form and lateral cavities characteristic of the sacral vertebræ of the present genus; whence I infer, from the different relative expanse of the neural canal, as shown in the figures of the vertebræ above compared, that the hind limbs were relatively less in *Bothriospondylus* than in *Iguanodon*. They, probably, came nearer to Crocodilian proportions.

A second more mutilated sacral centrum of *Bothriospondylus* (Pl. 62, figs. 4, 5, 6) shows the modification of that marked 4 in the sacrum of *Hylæosaurus* ('Dinosauria,' Pl. 38, figs. 1 and 2), in having the parapophysial expansion limited to one (*p*) on each side of the centrum. In the present genus its base occupies the anterior half of the lateral surface, instead of the smaller proportion shown in *Hylæosaurus;* it is also more depressed, and the entire centrum is flatter, though not in so great a degree as in the subject of Pl. 62 above described. Both ends of the present centrum are flat, and show a greater proportion of the smooth unconfluent condition than in the subject of Pl. 62, fig. 3. The supporting parts of the neural arch forming the roofs of each lateral cavity (Pl. 62, figs. 4 and 5, *f*) are broken off together with the arch itself, and but a small part of the neural surface (ib., figs. 4 and 5, *n*) is preserved.

This mutilation exposes the whole depth of the lateral excavations (ib., fig. 4, *f*, *f*) of the centrum, undermining, as it were, the base of the neural arch; and these show that the breadth of the centrum beneath that arch is reduced, about midway between the two ends, *a* and *b*, to half an inch, the breadth of the centrum at the fore end, *a*, being, when

* See '*Crocodilia*, Pl. 1D, fig. 6, sacral vertebra of *Crocodilus Hastingsiæ*.

† See '*Dinosauria*,' Pl. 25.

entire, 3 inches 3 lines. At the opposite or hinder end the breadth was less, and the height apparently greater, whence it may be inferred that this vertebra was near to the hinder end of the sacrum.

The right half of the anterior, flat, smooth but irregularly indented, articular surface of the centrum is nearly entire. Extending, as far as the origin of the pre-parapophysis, *p*, which is preserved, and wanting only part of its upper surface, the entire transverse extent can be estimated, as above noted.

The under surface of the centrum (Pl. 62, fig. 6) is more convex across than in the subject of fig. 1, Pl. 61, concomitantly with its greater extent in the present vertebra. The longitudinal contour of the under surface (Pl. 62, fig. 5) is more uniformly concave. The margin of both articular ends is eroded. The aperture of the lateral excavation (ib., fig. 4, *c'*) is 1 inch 5 lines in longitudinal extent; but the cavity is continued 10 lines further above the pre-parapophysis (ib., *p*); the depth of the excavation at the middle of the vertebra is 1 inch 3 lines. The smooth compact crust of the centrum passes, without fracture, over the free lateral tract (ib., fig. 5, *c'*). The vertically convex border of the floor of the cavity is somewhat thicker than in first-described sacral vertebra, but similarly shows a natural condition and contour. The upper surface of the floor of the cavity shows a fine crack (outside the letter *f* in fig. 4) as if the inner half of that floor, with the adjoining part of the centrum (*p*) supporting the base of the neural arch had been slightly depressed.

The proportion broken away from the left side of the present vertebra is indicated in outline in figs. 4 and 6.

The subject of figs. 1, 2, 3, Pl. 62, transmitted at the same time with the vertebræ above described, and from the same locality, I refer, from the superficial characters of the under surface and of one of the terminal surfaces of the centrum, to the same genus and species of *Dinosaur*, and it probably formed part of the same individual.

The flattened surface of the centrum, at *a*, fig. 2, in the irregular impressions of its otherwise smooth surface closely accords with the one, *b*, of the subject of fig. 5, to which it adapts itself sufficiently closely to suggest that it may have been ligamentously articulated thereto. The opposite surface (ib., fig. 1 and fig. 2, *b*) is not so impressed, is slightly convex and smoother, and indicates a joint with the succeeding vertebra admitting of more movement. I infer, therefore, that the present specimen is the centrum of the last sacral vertebra, and that the end articulating with the first caudal vertebra had resumed more of the usual vertical proportions of the centrum. The parapophysis (*p*), with the irregular syndesmosal surface, has a greater extent, both vertically and lengthwise. Above it extends the narrow fractured surface of the broken off base of the neurapophysis. The floor of the neural canal (fig. 1, *n*) is preserved, which is concave lengthwise as well as across, sinking somewhat into the substance of the centrum. Its diameter midway between the two ends is 7 lines.

The lateral excavations of the centrum appear to have ceased at this vertebra, and

probably were not resumed in the caudal series. It has been fractured and somewhat distorted by posthumous violence: but this has not affected the contour of the under surface of the centrum (ib., fig. 3), or the vertical proportions of this element, any more than in the case of the two previously described sacrals.

In four centrums of dorsal or dorso-lumbar vertebræ of *Bothriospondylus suffossus*, forming part of the same series transmitted from the Kimmeridge Clay of Swindon, the characteristic excavations are conspicuous and with longer apertures than in the sacral vertebræ, where these are interrupted by the broad articular parapophyses. No trace of the latter processes are present in the trunk vertebræ of which the type is selected for the subjects of Plate 63.

The centrum is subcompressed (fig. 2); its sides moderately concave lengthwise (fig. 1), with one end feebly convex, *a*, the opposite end rather more concave, *b*. I regard the latter as the hinder one, and the trunk-vertebræ to be, as in *Streptospondylus*, of the opisthocœlian type. The free surface of the centrum is smooth, save near the articular ends, where there are low longitudinal risings and shallow channels. The under surface (ib., fig. 4) is perforated by two or more small vascular (venous) canals near the articular ends.

The fore end (ib., fig. 2) has a somewhat irregular surface. The hind one, which has suffered less from compression (ib., fig. 3), shows a similar coarse pitting and rising at the central part of its surface, the peripheral part being smoother than that at the middle, which has yielded to pressure, the large cancelli there having been crushed in.

The bases of the neurapophyses (Pl. 63, *np*), commencing about three lines from the anterior end of the centrum, are continued to the posterior end. They have been anchylosed to the centrum and broken away. Posthumous pressure has crushed this specimen laterally and obliquely. Part of the floor of the neural canal is exposed (at *n*, *n*, fig. 5), and is continued outward, at *o*, where the spinal nerve has had issue. The narrowness of the tract of the centrum, between the lateral excavations, *f*, *f*, giving support to the coextensive parts supporting the neural arch, is a singular characteristic of the present genus, and made it difficult to conceive that a mere plate of bone like that between *f* and *np* in fig. 1, Pl. 63, would relate to the support of a neural arch. It recalled the structure of that part of the vertebræ in the thoracic-abdominal region of a *Chelonian*. What the character of such arch may have been we have yet to learn, in the present species, from better preserved specimens. Not a fragment recognisable as belonging to such portion of the vertebra could be found among the fossils sent up from the Kimmeridge locality at Swindon.

Two rather more crushed and distorted centrums show, nevertheless, an increase of transverse diameter indicative of their having come from a region of the spine near the sacrum. The centrum shows the same opisthocœlian type, the same wide and deep lateral excavations, undermining, as it were, the neural arch, an absence of transverse processes, and the fractured bases of anchylosed neurapophyses.

The "Swindon Brick and Tile Company's Works," whence, through the kindness of the managing director, James K. Shopland, Esq., the above-described fossils were obtained, are situated on land adjoining the Wilts and Berks Canal. The vertebræ were found, associated with remains of *Pliosaurus brachydeirus*, in the Kimmeridge clay, at a depth of fifteen feet. The clay here is of a deep black-blue; and a mass of lignite, seemingly derived from a crushed trunk of a tree, and burning like ordinary coal, was here discovered.

Order. *DINOSAURIA.*

Genus—Omosaurus.

Species—*Omosaurus armatus*, Owen ('Dinosauria,' Plates 64—75).

Shortly after the foregoing pages on *Bothriospondylus* had been penned I was favoured with the subjoined note,* announcing further discovery of larger bones in their Kimmeridge Clay works, followed by a liberal offer on the part of the Company † of such of these fossils as might be found worthy of being added to the Geological Collection in the Brltish Museum. Mr. William Davies, of that Department, was thereupon instructed to inspect the diggings, and, on his 'Report' of the appearances, was authorised to take the requisite steps to remove and transmit to the British Museum as much of the matrix as gave evidence or promise of containing organic remains. This operation

* "Swindon Brick and Tile Company,
"Swindon, Wilts; 23*rd May*, 1874.

"Dear Sir,

"I last year had the pleasure of sending you some Saurian Remains discovered in this Company's Kimmeridge Clay Pits, and I beg to inform you that we have just laid open other remains considered to be unusually large and fine, which are left *in situ*, carefully covered over.

"As exposure to light and air will, I fear, cause the remains to split and crumble, I should suggest your coming or sending some one to inspect them at once; the clay adjoining I will leave unworked until Wednesday next.

"I am, &c.,
"James K. Shopland.

"Professor Owen, British Museum."

† It is due to their enlightened liberality and prompt co-operation in applying to the advance of science whatever, in the course of the works, might aid therein, to subjoin the names of the Directors of the Company:—J. C. Townsend, Esq., Thomas K. Shopland, Esq., Henry Kinneir, Esq., Richard Rowley, Esq.

was carried out with Mr. Davies' experienced skill and judgment.* Some tons weight of matrix was transmitted to the British Museum, and occupied, during the remainder of the year, the practised chisel of Mr. Barlow, the mason-sculptor of the Geological Department, under the guidance and supervision of Mr. Waterhouse, Mr. Davies, and myself. The result was the extrication from these masses of the bones of one and the same individual dragon, or Saurian, and these form the subject of the present section.

They were found at a depth of ten feet from the surface soil covering the clay deposit, which deposit, where it surrounded the bones, presented unusual density and almost intractable hardness, and was traversed by fissures or cavities occupied by infiltrated spar, presenting in parts a septarian character. This condition of the matrix suggested that it might, in some degree, be due to the decomposition and exudation of the soft parts of the large reptile when buried in the clay sea-bed into which it had sunk; gaseous emanations might give rise to fissures or vacuities in the surrounding tenacious mass, into which the stalagmitic spar might subsequently infiltrate during the long ages of the condensation, petrifaction, and upheaval of the deposit; but cracks and cavities, from whatever cause, do become so occupied, as in the present local accumulation, and have received the name of 'septarian doggers.'

In the borings lately carried on at Netherfield, near Battle, Sussex, 660 feet of 'Kimmeridge Clay' were traversed before the 'Oxford Clay' was reached, without interposition of 'Coral Rag' or 'Coralline Oolite.'† This testimony to the time during which Kimmeridgian strata had been accumulated to such vertical extent gives free scope for surmise and speculation as to the long ages during which Pliosaurs, Cetiosaurs, Bothriospondylian and other enormous reptiles, lived and died in a world of which they seem to have been masters, as far as grades of organic life and power, acting at that epoch, have been determined. Other lines of variation and modification of the dragon type, besides the new one about to be defined, probably remain to be determined by ulterior research, and to reward the labour, skill, and science of investigators and collectors of Kimmeridgian remains.

Of the Dinosaurian genus and species, for which the name *Omosaurus armatus*‡ is proposed, parts of the vertebral column, the pelvis, a femur, and tibia, and almost all the bones of the left fore limb, have been worked out. The scapular arch, sternum, skull and teeth, and bones of the hind feet, are still desiderata. That not a single tooth

* See the processes described by him in his instructive 'Catalogue of Pleistocene Vertebrata in the Collection of Sir Antonio Brady,' 4to., 1874, p. 71.

† A thickness or vertical extent of 1050 feet is assigned to the combined 'upper' and 'lower' divisions of the Kimmeridge Clay, by the Rev. J. F. Blake, M.A., F.G.S., in his instructive memoir on this formation in England, 'Quarterly Journal of the Geological Society,' vol. xxxi, p. 196.

‡ Ὦμος, humerus; Σαυρος, lacertus: suggested by the unusual development of the muscular crests and processes of the arm-bone, perhaps in relation to the formidable weapon with which the fore limb appears to have been armed.

should have been met with in any part of the ossiferous matrix is much to be regretted, but one indulges the hope that teeth of *Omosaurus* may be one day recovered and be found implanted in their jaws.

Cervical Vertebra.—A portion of a neural arch and spine ('Dinosauria,' Pl. 64, figs. 1 and 2), with the right prezygapophysis, *z*, the left postzygapophysis, *z'*, the roof of the neural canal, *n*, and the entire neural spine, *n s*, might belong, from the shortness of the latter, to a caudal vertebra. But, from the indicated capacity of the neural canal and the aspects of the articular surfaces of the zygapophyses, I infer the specimen to have belonged to a vertebra from the cervical region.

The length of the neural arch is 7 inches 6 lines; the height of the neural spine is 3 inches 6 lines; its fore-and-aft breadth, at the middle, is 2 inches; at the free end 3 inches; the thickness, transversely, is 1 inch: this is at the hind border, near the summit; it slightly decreases toward the base, and the whole spine thins toward the fore part. The summit, which is rugged, gains in extent by being produced backward.

The diameter of the neural canal appears to have been $1\frac{1}{2}$ inches. The prezygapophysis, *z*, projects about half an inch in advance of the base of the diapophysis, *d*, *d*, which here has an antero-posterior extent of 2 inches 6 lines. The outer border of the prezygapophysis is slightly raised above the base of the diapophysis; the articular surface of the prezygapophysis looks upward and slightly inward; it is not quite flat, but feebly convex. The articular surface of the postzygapophysis, *z'*, is in the same degree concave. This surface looks downward and a little outward.

In the figure of the upper surface of a cervical vertebra of a large Monitor Lizard (*Varanus niloticus*, Cuv., ib., fig. 4) I have indicated by dotted lines the course of the fractures which have reduced the corresponding vertebra of the huge Dinosaur to the condition shown in Fig. 2. The relation of the origin of the diapophysis, *d*, to the prezygapophysis, *z*, is the same in both the recent and fossil Saurian; but the breadth across the zygapophyses was relatively less to the length of the neural arch in *Omosaurus*.

The fragmentary condition of this solitary evidence of the region of the vertebral column supporting the skull seems to point to some strange violence by which the head of the Omosaur has become severed from the trunk, and its frame-work probably borne to some part of the old sea-bed at a distance from the rest of the body.

Dorsal Vertebræ.—Amongst the characters of the Order *Dinosauria* is a lofty and buttressed neural arch in a great proportion of the trunk-vertebræ; the characters of the articular ends of the centrums relate to species or to parts of the vertebral column of the same species. The ordinal character is illustrated in the *Iguanodon* ('Dinosauria,' Pl. 3); in the *Megalosaurus* (ib., Pl. 24); in the *Hylæosaurus* (ib. Pl. 37), *et seq.*

This character is strongly marked in dorsal vertebræ of the present genus, and with modifications which could hardly have been illustrated or made clear without the above-cited figures of the vertebræ of previously defined Dinosaurian genera. In these, however, the degree of complexity of the neural platform varies; it is least marked in the smaller and more crocodilioid genus *Scelidosaurus* (*Dinosauria*, Plates 51 and 52).

The vertebra of *Omosaurus*—the subject of '*Dinosauria*,' Plates 65, fig. 1, and 66—has come from the middle of the trunk. This is inferred from the position of the surface, *p*, for the head of the rib, which has risen from the centrum, or base of the neural arch, to near its summit, where, with its diapophysial productions, *d, d*, the arch expands to a breadth of 14 inches 6 lines; the breadth (in the same direction, transversely) of the centrum being 5 inches 3 lines. The vertical diameter of the middle of the articular surface of the centrum is 4 inches 9 lines; the height of the vertebra to the base of the neural spine is 11 inches. This spine has been worked out entire only in the above-described cervical and caudal vertebræ; but there are indications justifying an estimate of its length in the dorsal series, at from 6 to 8 inches.

Thus, the dorsal vertebra, affording material for the present description, which has a breadth, as above shown, of one foot two and a half inches, had a height of at least one foot and a half.

The fore-and-aft dimension of the centrum (Pl. 66, fig. 3) is 4 inches. The anterior surface (ib., *a*), where it varies from flatness, is toward convexity, but in the feeblest degree; the posterior surface (ib., *b*) is very slightly, but more equably, concave. The free surface of the centrum is moderately concave longitudinally; slightly depressed at *f*, beneath the base of the neural arch. The tissue throughout the vertebra is more compact than in *Cetiosaurus* ('*Dinosauria*,' Pl. 76).

The neurapophyses (Pl. 65, fig. 1, *n p*) have coalesced with the centrum; they quickly narrow transversely, above their base, to a thickness of half an inch, more gradually contract in fore-and-aft dimension (Pl. 66, fig. 2, *n p*) to two inches and a half. Overarching the neural canal (Pl. 65, fig. 1, *n*), they meet and coalesce about one inch and nine lines above the centrum, whence their compact coalesced mass rises above the crown of the arch, expanding to a height of five inches (posteriorly, Pl. 66, fig. 1) before giving off the neural spine (ib., *n s*).

At three inches above the base the outer surface of the neurapophysis is excavated by a smooth oval cavity (ib., fig. 2, *p*), 1 inch 9 lines in vertical, 1 inch 6 lines in transverse, diameter, and about 8 lines in depth. To this cavity was adapted the 'head of the rib:' for this part there is no parapophysis, or outstanding process. Below the capitular cavity the outer surface of the neurapophysis is divided from the hinder surface by a low obtuse ridge or angle (ib., ib., *e*); a broader ridge (ib., ib., *a*), also low and obtuse, rises along the middle of the outer surface of the neurapophysis, and expands to form the lower margin of the costal pit. In advance of this pit the

neurapophysis extends forward to form the prezygapophysis (ib., and Pl. 65, fig. 1, *z*). The ridge (*e*), rising to the costal pit, forms or extends its hind border and is thence continued, expanding or thickening, into the ridge which forms the diapophysial buttress, *f*. The ridge (Pl. 66, fig. 3, *a*) does not, in this vertebra, combine with the ridge, *e*, to form the buttress, as in the *Iguanodon* ('Dinosauria,' Pl. 3), but appears as a shorter independent ridge. A median ridge (Pl. 65, fig. 1, *r*) rises from above the interspace of the prezygapophyses to the neural spine, *n s*. Another median ridge (Pl. 66, fig. 1, *s*) extends along the back of the neural arch and rises to the interspace of the postzygapophyses, *z'*, *z'*. The chief expanse of the summit of the neural arch in the antero-posterior direction is a zygapophysial one (Pl. 66, fig. 2, *z*, *z'*); in the transverse direction it is a diapophysial expansion (ib., fig. 1, *d*, *d*).

Each diapophysis is three-sided; the broadest facet is on the upper side, forming with the zygapophyses the neural platform. External to the zygapophyses this surface is 2½ inches from before backward; it is flat. The postinferior surface (Pl. 66, fig. 1, *f*, *d*) is in that direction concave, most so below the postzygapophyses, *z'*, and growing shallower to the tumid extremity, *d*, of the transverse process. The least fore-and-aft diameter of this surface of the diapophysis is 2 inches 3 lines, that of the antero-inferior surface is 1 inch 5 lines; this is feebly concave across, and is divided lengthwise for part of its extent by the zygapophysial ridge (Pl. 65, fig. 1, *t*).

The free end of the diapophysis is swollen and tuberous; a well-marked facet (Pl. 65, fig. 1, *d*, and Pl. 66, fig. 2, *d*) cuts the lower part obliquely; it is of a rhomboid shape, nearly flat, and is roughened for the ligamentous attachment of the 'tubercle of the rib;' it measures 2½ inches by 1 inch 9 lines.

The postzygapophyses (Pl. 66, fig. 1, *z' z'*) are formed by an expansion backward of the neural platform, the pair of processes being indicated by a medial notch; they are more clearly defined by their flat articular surfaces, which are subtriangular in shape, the angles being rounded off; their longest diameter is 2 inches: they look outward and downward.

The prezygapophyses (Pl. 65, fig. 1, *z*, *z*) have been mutilated in the present vertebra, but the extent of their basal origin, 2 inches, may be traced; they are more distinct productions of the neural platform, which abruptly sinks to the level of their medial borders.

The anterior basal ridge (ib., *r*) of the neural spine begins at this lower part of the platform, which it divides into a pair of hollows. The spine rises freely from the broader upper level of the platform. Its base here has a fore-and-aft extent of 3 inches 8 lines. The hind border of the spine is rather sharp; the thickest part of the body of the spine is 9 lines; its free termination was probably, from the analogy of a caudal vertebra subsequently to be described, swollen and tuberous.

A vertebral centrum and a portion of the neural arch, from the same region of the spinal column, repeat the characters, so far as they are shown, of the less fragmentary

vertebra above described and figured. Two views of the centrum, of half the natural size, are given in Plate 65, figs. 2 and 3. The capacity of the neural canal (fig. 2, *n*) is worthy of note; it is rather Mammalian than Saurian, and implies a great development and vigour of the muscular system.

LUMBAR VERTEBRÆ.—The last lumbar vertebra ('*Dinosauria*,' Pl. 72, *l*) appears to be confluent with the first sacral (ib., *s* 1). Its centrum is 3 inches in longitudinal extent; the side is slightly depressed below the base of the neural arch, from which extends a lumbar rib (ib., *l*, *p l*) 9 inches in length; this is 1½ inches in breadth at three inches distance from its free extremity.

This lumbar rib, and also that of the antecedent lumbar vertebra, are straight and extend transversely to the axis of the vertebral column. The distance in a straight line from the hæmal surface of the lumbar centrum to the end of the last lumbar rib is 1 foot 3 inches.

SACRAL VERTEBRÆ.—These are five in number (ib., *s*1—*s*5), coalesced together, and seemingly with their pleurapophyses. The antero-posterior extent of the five sacral centrums is 1 foot 4½ inches, each centrum averaging 3½ inches in length. After the first they increase in breadth and decrease in the transverse convexity of the hæmal surface, the middle ones showing traces there of a shallow longitudinal hæmal channel with thick low convex borders. The interspace between the heads of the third pair of sacral ribs (ib., *pl* 3) is 7 inches, between the fifth pair it is 6 inches.

Fractures of the mass of matrix enveloping the pelvis exposed the close cetiosaurian texture of these vertebræ and the shape, in some degree, of the neural canal in a portion of the sacrum. One (fifth) sacral vertebra was thus divided lengthwise through the centrum, neural arch, and spine, and yielded the following dimensions:—Vertical extent 1 foot 5 inches; ib., length of neural spine, 6 inches; antero-posterior diameter of do., 3 inches 6 lines. This spine for a great part of its length was not in contact with the antecedent neural spine. The neural canal partially depresses the upper surface of the centrum of each sacral vertebra, probably in relation to venous sinuses rather than to ganglionic enlargements of the myelon. The vertical diameter of the neural canal where it dips down into the centrum is 2 inches 3 lines; in the ordinary course of the canal, it is 1 inch 2 lines: but, as the fracture affording this view was not exactly along the middle of the vertebra, the canal might gain more depth at that part.

The central part of the sacral centrum shows a rather coarser cancellous texture than the rest, or than is seen in any part of the centrum of an anterior caudal vertebra (Pl. 75, fig. 1).

What appears to be the first sacral rib (Pl. 72, pl. 1) is slightly dislocated hæmad, and probably, at the same time, bent forward obliquely from above downward and backward in a greater degree than natural, the hæmal end of the articular surface

projecting a couple of inches in advance of the second sacral rib (ib., *pl.* 2). The long or vertical diameter of the head or articular end of this rib-plate is 6 inches; at 3 inches of its outward course it expands to a breadth of $7\frac{1}{2}$ inches by a convex extension of the fore border, which appears to have articulated like a rib-tubercle with the neural arch, and to have been underlapped by part of the ilium (Pl. 72, *a*). Beyond this point the rib-plate, as it approaches the acetabulum, diminishes in breadth but increases in thickness and seems to develop from its hæmal side a broad, transversely convex ridge or buttress (ib., pl. 1) 5 inches long by $2\frac{1}{2}$ broad at the distal end, which abuts upon the fore and hæmal angle of the acetabulum, *e*. A process of the antacetabular part of the ilium (ib., *a*) is continued inward and hæmad to articulate with the upper border of this first broad, sacral rib; an oblong vacuity, 4 inches by 2 inches, intervenes between this process of the ilium and the acetabulum. The second sacral rib (ib., *pl.* 2) is indicated by the part of the plate posterior to *pl.* 1.

The proximal portion of this seemingly single broad and bifid pleurapophysis is applied to the greater part of the sides of the two anterior sacral centrums (ib., *s* 1, *s* 2), showing it to be the confluence of two pleurapophyses, the part described as the convex side or buttress being the distal articular end of the anterior of these.

On this view the next independent sacral rib would be the third (ib., pl. 3); its proximal end is expanded and applied by a similar, but not so great, obliquity to the side of the third sacral centrum (ib., *s* 3), having a breadth of 3 inches with a thickness of nearly 2 inches, but contracting to a narrow rounded hæmal border, retaining above this part a thickness of 1 inch, then expanding to a breadth of 3 inches to abut upon the hæmal border of the acetabular part of the ilium, filling the interval between the like extremities of the second and fourth sacral ribs. The direction of the third pair is nearly transversely outward. The length of the interspace between the second and third ribs is 6 inches; the fore-and-aft breadth is $3\frac{1}{2}$ inches; it narrows towards the acetabulum, where the distal expansions of these ribbed buttresses come into contact and seemingly coalesce with each other, and similarly narrows to their proximal expansions, thus showing an elliptical shape.

The head of the fourth sacral rib (ib., pl. 4) is applied to the whole side of the corresponding centrum (*s* 4), and is $3\frac{1}{2}$ inches in fore-and-aft diameter; from this the rib contracts to the form of a subvertical thick plate, and then expands to a breadth of 4 inches applied to, and confluent with, the lower border of the acetabulum and a considerable extent of the medial surface of the ilium rising therefrom.

The fifth sacral rib, with the head reduced to $2\frac{1}{2}$ inches in fore-and-aft extent, is applied to the side of the last sacral centrum (*s* 5). This rib, contracting at first like the previous ones, then expands as it extends outwards and slightly backwards, chiefly in the vertical direction, to be applied for an extent of 5 inches to the part of the acetabulum to which the ischium is articulated. A considerable part of the right ischium (ib. 63) is retained, dislocated a few inches from the articular facets (ib., *b*, *c*),

and thrust a little mesiad and forward. This bone will be subsequently described showing the proportion of the acetabular cavity contributed by it.

Anterior to the pelvis is a dislocated group of eight hinder trunk-vertebræ, each retaining more or less of its neural arch and processes. On the right side of the pelvis a complete dorsal vertebra is exposed, measuring 1 foot 5 inches in length and 13 inches in breadth, between the diapophyses. The centrum is 3 inches 9 lines in length, 5 inches in breadth, $4\frac{1}{2}$ inches in height, to the base of the neural canal; the hinder outlet of this is pyriform, the apex about $2\frac{1}{2}$ inches in vertical, and $1\frac{1}{2}$ incehe in transverse, diameters. From the floor of the neural canal to the base of the spine is 8 inches; the length of the spine is 5 inches.

Beyond this dorsal vertebra is the body of a caudal one, showing a greater degree of concavity of the fore surface of the centrum, which has a breadth of 6 inches.

Behind the sacrum is a dislocated group of four caudal vertebræ, mainly agreeing in character with the subject of Pls. 67 and 68.

Caudal Vertebræ.—The vertebra of *Omosaurus* which has been most perfectly wrought out of the matrix is one from the base of the tail; it was in the same block with the sacrum, not far from the hind part of the pelvis.

This anterior caudal vertebra forms the subject of 'Dinosauria,' Pls. 67 and 68, of the natural size; and I here subjoin, also, the following admeasurements:

	In.	Lines.
Height or vertical extent of the entire vertebra	14	9
Breadth of ditto	14	6
Length at the zygapophyses, giving extreme length of neural arch	4	2
Centrum, length, lower surface	2	10
,, ,, upper surface	2	5
,, breadth, anterior surface	5	8
,, ,, posterior surface	6	0
,, height, anterior surface	4	5
,, ,, posterior surface	4	6
Neural canal, vertical diameter	2	0
,, transverse diameter, least	1	4
Neural arch, breadth at upper level of centrum	5	8
,, ,, across prezygapophyses	4	5
,, ,, ,, postzygapophyses	2	2
Pleurapophysis, length from base to apex	4	0
,, depth from tubercle to under surface	2	3
,, thickness, extreme, at base	1	6
,, ,, at tubercle	0	10
,, ,, below tubercle	0	8

	In.	Lines.
Neural spine, length from fore part of base . . .	7	1
,, ,, hind part of base . . .	5	6
,, fore-and-aft breadth at mid-length . .	1	8
,, transverse breadth, at mid-length . .	1	0
,, ,, at tuberous end . .	2	5

A comparison of such of the above admeasurements as have been recorded of trunk-vertebræ shows that the caudal ones become shortened, at least, at the basal part of the tail. As the length of this appendage would depend upon the number of vertebræ, and especially of those reduced nearly to the centrum, which might again gain in length, it would be premature, on present evidence, to hazard an opinion on this dimension in *Omosaurus armatus.* But the size of the outstanding parts for muscular attachments indicates great power in the tail, which would probably be exercised, as in the largest living Saurians, in delivering deadly strokes on land, as well as in cleaving a rapid course through the watery element.

The centrum is transversely elliptical, with both upper and under surfaces sloping from before downward and backward from the terminal articular planes, these being vertical. Of them the anterior (Pl. 67, fig. 1, *a*) is flat, with a slight convexity toward the periphery and a shallow transverse groove at the centre; the posterior surface (Pl. 68, fig. 1, *b*) is more decidedly, though but slightly concave; the deepest part here, being along a central transverse groove, with a slight upward bend, like that on the opposite surface. A rugged border for the attachment of a capsular ligament projects from two to five lines beyond the articular tract. This, though smoother than any part of the free surface of the centrum, has evidently, by its inequalities or sculpturing, related to a syndesmosal joint, as in the *Chelone* and *Mammalia*, not to a synovial one as in *Crocodilia.* Between the fore and hind borders of the centrum the lower surface is antero-posteriorly concave (Pl. 68, fig. 2), the concavity narrowing as it approaches the line of confluence of the pleurapophysis (ib., ib., *pl*). This line begins below, half way between the under and upper surfaces of the centrum, and extends upward, approaching obliquely the fore surface (ib., *a*) to overlap and be lost (by anchylosis) in the base of the neurapophysis; a feeble trace of the primitive separation of this element may be discerned at the hinder outlet of the neural canal (ib., fig. 1, *npl*). The pleurapophysial line of confluence is more distinctly traceable; the base of the pleurapophysis, representing the head of the caudal riblet, is broadest below, and there extends nearer the posterior than the anterior surface of the centrum; but, as it rises, it narrows and leaves a larger proportion of the post-lateral surface of the centrum free. The 'tubercle' (*t*) of the rib is a well-marked rough prominence at which the upper border of the rib descends at an open angle with the 'neck' to its obtuse apex. The under border of the riblet is gently concave lengthwise. No diapophysis has been developed, in this vertebra, to afford abutment to the tubercle.

Each neurapophysis at its confluence with the centrum gives a triangular horizontal section (Pl. 67, fig. 3, *np*), the base of the triangle, 1 inch 5 lines, being anterior, the obtuse apex behind. The inner, shorter side, next the neural canal, is parallel with its fellow and the trunk's axis, the outer side, 2 inches 9 lines in extent, slopes from the broad fore part backward and mesiad to the hind margin of the neural arch.

From the upper and anterior forwardly sloping part of each neurapophysis the prezygapophysis (*z*) is developed; it is short, thick, obtuse, with a flat articular surface, looking upward, inward, and slightly forward; subcircular, an inch in diameter. From the narrower hind part of the neural arch the common base of the pair of postzygapophyses (*z′*, *z′*) rises, expanding to form their articular surfaces, which look in directions opposite to those in front. The hind surface of the common base of these articular expansions has a wide and deep vertical channel.*

The neural spine (*ns*) is subquadrate at its base, with the lateral angles broadly rounded off (Pl. 68, fig. 2, *ns*). The line of attachment of the base of the spine rises from before backward (ib., fig. 3). A median anterior ridge (Pl. 67, fig. 1, *x*) strengthens the lower half of that surface, as a similar but thicker ridge (Pl. 68, figs. 1 and 3, *s*) does the posterior corresponding tract. Where these ridges cease the spine begins to expand into its rough obtuse summit, chiefly transversely, so as to give it an elliptical contour extended in that direction (Pl. 67, fig. 2).

The foremost of the caudal vertebræ remains in the block of matrix with the sacrum. The present I take to be the second of the series. There is no trace of hypapophysis for a hæmal arch in either of these caudals (the under surface of the centrum of the second is figured in Pl. 67, fig. 4). In *Scelidosaurus* the first or foremost caudal alone is devoid of hæmal arch; in the second caudal the lower part of the hind border is touched by the smaller anterior facet on the base of the hæmapophysis.

In the few succeeding caudal vertebræ, with diminution of general size, the vertical extent and the length of the pleurapophyses decrease in a greater ratio. A larger proportion of the side of the centrum is left free below the rib's confluence therewith; and this free surface of the centrum shows, as in the specimen selected for Pl. 69, an upper (*c*) and a lower (*c′*) depression. The transverse extent of the centrum decreases without corresponding loss of vertical extent. The hind surface of the centrum (ib., fig. 2) becomes more concave, without corresponding increase of convexity of the fore surface. The contour of the hind surface approaches the subhexagonal.

The anterior and posterior ridges of the neural spine subside; the fore ridge is longest retained, but shrinks toward the base of the spine, as at *r*, fig. 1. In the subject of this Plate, as in three other caudals extracted from the matrix, the neural spine has been bent to one side, as shown in Pl. 69, fig. 2. This distortion I conceive to be due to movements of the matrix after the fossil had been inclosed thereby and become petrified therewith. For,

* It is possible that a similar facet may have been ligamentously attached to the rough surface extended from the lower margin of the terminal surface.

being thus supported at every point by the matrix, during the slow and continuous partial pressure, the spine has yielded and bent without breaking. In one instance the sustaining neural arch has suffered partial fracture at the side (ib., fig. 1), toward which the spine has been bent.

A thickening at the outer side of the neurapophysis, feebly indicated in the larger anterior caudals (Pl. 68, fig. 2, *np*), becomes more prominent near the base of the prezygapophysis, as at *np*, figs. 1 and 2, Pl. 69, in the succeeding smaller vertebræ, in which the hypapophyses are more distinctly marked.

These articular protuberances (ib., figs. 1—3, *hy*) form a pair at the hind border of the inferior surface of the centrum ; the articular tracts at the fore border of that surface are barely defined, or may be indicated by an extension backward of the rough marginal syndesmosal tract.

The caudal vertebra in Pl. 69 is figured a little more than half the natural size. The answerable caudals in the great Monitor Lizard (*Varanus niloticus*) are given, of the natural size, in figs. 4 and 5.

The hæmal arch in the caudal vertebra, with a centrum $5\frac{1}{2}$ inches in vertical extent, has the same length. The hæmapophyses (ib., fig. 2, *h*) are $2\frac{2}{3}$rd inches in length before coalescing to form the spine (ib. ib., *hs*), which is $2\frac{1}{3}$rd inches in length in the subject of the Plate ; it was probably longer when quite entire. But the length of the arch and spine was plainly less in proportion to the vertical extent of the rest of the vertebra than in *Cetiosaurus longus*. The hypapophyses are accordingly relatively smaller, and are limited to a narrower transverse extent of the inferior surface of the centrum (ib., fig. 3, *hy*) than in *Cetiosaurus*, or in the recent *Varanus* (Pl. 69, fig. 4, *hy*). In *Cetiosaurus brevis* the hypapophysial facets (*h*, *h*) are broader and wider apart than in *Cetiosaurus longus*.

In *Iguanodon* the reverse conditions prevail. These surfaces have become confluent, and present a single bilobed facet to the similarly confluent surfaces on the bases of the right and left hæmapophyses (‘*Dinosauria*,’ Pl. 13). Both neural and hæmal spines are relatively longer in *Iguanodon ;* and the neural spine springs from a smaller proportion of the hind part of the neural arch at a much greater distance behind the prezygapophyses than in *Omosaurus*. The caudal vertebræ differ less from each other in *Omosaurus* and *Cetiosaurus* than they do in either of these genera as compared with *Iguanodon*.

As in the case of *Cetiosaurus longus* and other previously described Dinosaurian subjects, I have selected the best preserved specimen of an average-sized vertebra for figures of the natural size, the requisite comparisons being much facilitated, and accurate results ensured, by such life-size figures.

Humerus.—Of the skull, teeth, or scapular arch of *Omosaurus* I have not as yet received evidence. The humerus and some other bones of the left fore limb (‘*Dinosauria*,’ Pl. 70) have been relieved from the matrix in a more or less complete state.

The *humerus* (ib., figs. 1—5) is remarkable for its breadth, especially at the proximal half, compared with the length. The articular surfaces at both ends have been more or less abraded. That at the proximal end (figs. 1 and 2, *a* and fig. 3, *a*) shows the elongate oval form, with the larger end, *c*, toward the ulnar aspect, narrowing to the beginning of the great radial crest, *b′*, *b′*, as in *Crocodilus, Varanus,* and most existing Saurians; as in these, also, the head projects somewhat toward the anconal surface (as at *a*, fig. 2); but the prominent part of the shaft continued therefrom is less marked than in *Cetiosaurus longus* (p. 585, fig. 4).

The radial tuberosity (Pl. 70, figs. 1 and 2, *b*) is not developed distinctly as such, but, as in *Crocodilus* and *Varanus* (ib., fig. 6, *b*), is the beginning of a plate or crest of bone, answering apparently to both the deltoid and pectoral in Mammals, which plate extends considerably radiad, but with less inflection palmad, than in *Crocodilus* or *Varanus,* so that more of its breadth is seen in a direct palmar view, as in fig. 1, than in the Pterodactyle or the above existing Reptiles. It has a certain forward or palmar bend, and subsides a little below the middle of the shaft.

From the proximal beginning, *b*, of this great crest, a broad tuberous rising (ib., fig. 2, *d*) projects anconad, and is continued, narrowing obliquely distad, to terminate or subside at the radial side of the shaft, close to the termination of the crest *b′*. The tuberosity and ridge, *d*, *d′*, might be regarded as 'deltoidean,' as distinct from the 'pectoral' *b*, *b′*, save that its position is anconal instead of palmar. There is a rudiment or indication of this 'anconal ridge' in the humerus of the Crocodile, and a shorter one in *Varanus.* In the latter existing Saurian it gives origin to a muscle answering to the external 'head' or portion of the '*triceps extensor cubiti*' in Mammals.

The ulnar tuberosity extends ulnad and distad as a thick tuberous ridge, which terminates more abruptly than the radial crest, at *c*, figs. 1 and 2, about seven inches beyond the proximal end. The broad surface of the humerus between the crests is rather concave across on the palmar surface, somewhat more convex on the anconal surface, which is interrupted by the 'anconal or tricipital tuberosity and ridge.'

The shaft at its narrowest part presents in section the form given in fig. 5, Pl. 70, being almost flat, palmad and convex, anconad, transversely. It soon begins to expand into the distal end of the bone. The crest, *e*, simulates the 'supinator' one in Mammals, and is not perforated, as is the answerable disto-radial crest in some existing Saurians. Such perforation is very small in *Varanus* (ib., fig. 6, *e′*). There is no indication of this vascular or nervous canal in *Omosaurus,* and the crest is relatively shorter than in *Varanus.* The ulnar expansion, *f*, of the distal end is thick and tuberous.

Sufficient of the radial condyle, *g*, remains to show its Saurian extension palmad, and its convexity in *Omosaurus* (ib., fig. 4); the precise form and extent of the less prominent ulnar condyle or trochlea is not definable.

The texture of the shaft of this humerus, as exposed by the fracture across its middle

narrowest part, is compactly dense; there is a small medullary cavity (fig. 5) which seems to have but a short longitudinal extent.

A deep anconal depression (ib., fig. 2, *i*), marks that aspect of the distal expansion in a greater degree than in any Crocodilian, Lacertian, Dinosaurian, or Pterosaurian humerus that, as yet, has come under my notice; it gives to this part of the humerus of *Omosaurus* something of a Mammalian character.

The following are admeasurements of the humerus:

	Ft.	In.	Lines.
Length	2	9	0
Breadth across radial or pectoral crest . .	1	6	0
,, ,, distal end . . .	0	11	0
,, ,, middle of shaft . .	0	5	6
Girth of ,, . . .	1	6	0
Length of base of radial or pectoral crest . .	1	4	0
,, ulnar crest . . .	0	8	0

The figures of this bone on Pl. 70 are reduced to one fourth of the natural size.

Although I should have hesitated to found a genus or generic term on a solitary limb-bone if such distinction had not been supported by the vertebral characters, yet the features were so much more strongly marked in the present than in previously described or figured humeri as to have afforded a better excuse for such taxonomic deduction, which ought to rest, and, as a rule, can only safely do so, on characters afforded by associated parts of the skeleton or teeth.

Mutilated as are the humeri discovered with unquestionable vertebræ of *Cetiosaurus longus* in the Geological Museum of Oxford, justifying the conclusion that they belonged to the same individual, they are unmistakably distinct in character from that bone in *Omosaurus.*

Although the radial or pectoral ridge be broken away in the subjects of figs. 4 and 5, p. 585 (*Cetiosaurus*), its base has a minor relative extent than in *Omosaurus;* the shaft beyond that ridge expands more gradually into the distal end; the entire length of the bone—4 feet 4 inches in *Cetiosaurus longus*—is greater in proportion to the breadth or thickness of the shaft.

The slender character of the humerus is more marked in that bone which chiefly represents Mantell's genus *Pelorosaurus* ('*Dinosauria*,' Pl. 49), in which the radial or pectoral crest (ib., fig. 2, *d*) subsides above the middle of the shaft, encroaching, as in the *Crocodile*, *Varanus*, and Pterodactyle, upon the palmar surface of the bone. The humerus of *Iguanodon* ('*Dinosauria*,' Pl. 19) is still less robust in proportion to its length, not to mention its inferior size as compared with associated dorsal vertebræ, than in *Omosaurus.*

In *Hylæosaurus* we find the nearest approach to *Omosaurus* in the proportion of the length of the humerus giving attachment to the great tuberous crests from the radial and ulnar sides of its proximal part. But in the Isle of Wight specimens referred, with doubt, to that Dinosaur, the radial crest is more strongly, and, in reference to its Saurian nature, more typically twisted palmad than in the huger Kimmeridgian genus. It shows a tuberous thickening anconad of its distal end, in the place of the ridge, *d'*, fig. 2, Pl. 70, in *Omosaurus*.

Radius.—This antibrachial bone in *Omosaurus* (ib., figs. 7—11) has a subcompressed shaft, expanding moderately and almost equally into the two articular ends, as far as their degree of conservation shows; but it is probable that the more mutilated distal end (fig. 10) when entire would give a somewhat greater breadth than the proximal one or 'head.' This (ib., fig. 9) is of a narrow subelliptic shape. A small part of the concave articular surface, *a*, for the radial condyle of the humerus, is preserved. The anconal surface of the shaft (fig. 7) is feebly divided at its distal two thirds into two facets by a low rising, hardly to be called a ridge, beginning at the middle of that surface at its proximal third and inclining as it descends toward the radial border of the distal end. The concavity of both borders, and especially of the ulnar one, narrows transversely the shaft, but this preserves more equably its ancono-palmar thickness (see the section of the middle of the shaft in fig. 11). The lateral facet (fig. 8, *b*) at the proximal end for articulation with the ulna is more convex than is usual in *Reptilia*.

The surface (ib., fig. 8, *e*) for the insertion of the biceps tendon is well defined. The thenal prominence (ib., figs. 8 and 10, *f*) extending or deepening the cup, *g*, for the scaphoid, is strongly developed, and is thicker than usual, as far as it is preserved. Its outer surface is roughened, as if for the ligamentous attachment of some bone, such surface extending to the angle, *g* (fig. 8), at the broadest part of the distal end of the radius.

Ulna.—The proximal extension of the articular cup (Pl. 70, fig. 13, *a*) upon an anconal or olecranal production marks this bone as strongly as in *Varanus* (ib., fig. 15, *a*) but the excavation (*c*) of the shaft below the proximal end is differently situated. It would seem as if the ulnar or outer border of that depression in *Varanus* (ib., fig. 15) had been moved or extended palmad, in *Omosaurus*, toward the narrower, palmar, surface of the bone; and to such an extent that part of this excavation comes into view from the ulnar side, as at *c*, fig. 14. This excavation is continued distad for more than half the length of the bone (*c*, *c'*). Below this part the shaft assumes a subtriedral form; and its anconal border bends toward that aspect as it approaches the carpus. The articular surface for this segment of the fore limb is wholly destroyed.

Manus.—Of the carpal bones have been extracted a left scaphoid, left cuneiform, and left unciform. Of these three large wrist-bones the scaphoid is the smallest, as in

Varanus, not the largest, as in *Crocodilus*, in which it is connate with the trapezium and trapezoides.

The proximal surface for the radius is more uniformly and less boldly convex; the opposite articular surfaces for the trapezium and lunare is more deeply concave. The outer (ulnar) surface is elongate, narrow, and is the smallest on the bone; it seems barely to have touched the cuneiform, which is here, as in *Varanus*, the largest of the carpals.

The free broader radial surface of the scaphoid is flattened and roughened, and seems to have continued, distad, the corresponding surface of the radius itself, which is on the radial side of the distal end of that antibrachial bone (Pl. 70, fig. 8, *g*).

The length (transverse extent) of the scaphoid is 5 inches; the extreme (ancono-palmar) breadth is 3 inches; the extreme proximo-distal extent (on the rough flat surface) is 1 inch 10 lines.

The cuneiform is a massive cuboidal bone, with a proximal surface less concave for the ulna than in *Varanus*, but with as deep an opposite (distal) concavity for the division of the unciforme which supports the fourth digit. There is an approach to the crocodilian character of the bone in the increase of the distal part or surface. The transverse extent of the bone there is 4 inches 9 lines; that of the proximal surface being 4 inches; the ancono-palmar diameter of the bone is 3 inches 9 lines; the proximo-distal diameter is 3 inches 10 lines.

The unciform seems, as in the Crocodile, to have supported both fourth and fifth metacarpals, not to have been divided to afford articulations for these bones on separate portions. Its transverse extent in *Omosaurus* is 6 inches 4 lines; the other dimensions closely correspond with those of the cuneiform carpal.

The digits of a hind foot are longer, as a general rule, than those of a fore foot in existing Saurian Reptiles, and the same proportion has been demonstrated in the fore and hind feet of some extinct Dinosauria.* The proportions, at least, of the metatarsals in *Hylæosaurus* and *Scelidosaurus* support a belief that those of the metacarpals would be as in the homologous bones of *Iguanodon*.

Of the five metapodial bones of *Omosaurus* which have been wrought clear out of the matrix not any show a length as compared with the breadth which exceeds that of the metacarpal of the first digit in the fore-foot of *Iguanodon* ('*Dinosauria*,' Pl. 48, fig. 1, *m*); and the homologues of the intermediate metacarpals are shorter in proportion to their breadth than in *Iguanodon*.

I conclude, therefore, that the above metapodials of *Omosaurus* are metacarpals, that the digits were less unequal in length, and the whole fore-foot was more massive and elephantine in its proportions, in *Omosaurus* than in *Iguanodon*.

A metacarpal ('*Dinosauria*,' Pl. 71, figs. 3—6) has a flattened proximal surface (ib., fig. 5) of a subtriangular shape, slightly convex near its radial (*r*) and anconal (*a*) peri-

* *Iguanodon*, '*Dinosauria*,' Pl. 45; *Hylæosaurus*, '*Dinosauria*,' Pl. 44; *Scelidosaurus*, &c.

phery slightly concave toward the palmar border (*p*), which is broken away, the articular surface being continued a short way upon the ulnar (*u*) side of the shaft for junction with the second metacarpal.

The articular surface is pitted with small deepish depressions, as in most great Saurians, where the joint surfaces seem to have been more syndesmosal than synovial. The transverse and ancono-thenal diameters of the proximal surface are equal, each being 3 inches 6 lines; but, had the ulnar border been entire, the transverse diameter would have somewhat exceeded the other.

The short thick shaft of this bone is three-sided; one side extends obliquely from the ancono-ulnar (fig. 3, *au*) angle to the radio-palmar (*rp*) angle, with a transverse convexity; the second, or palmar, side (fig. 4, *p*) is less convex across; the third, or ulnar side, is flat across at the middle part, and somewhat concave near the two expanded ends of the bone. All these surfaces are concave lengthwise, the palmar one least so; but the proximal half of this (fig. 4, *p*, *p'*) has been crushed.

The distal articular expansion (fig. 6), almost flat transversely at its anconal part (*a*), begins to be concave at the middle of the distal surface (*b*), and this deepening to the palmar one (*p*) divides the joint there into a pair of convex trochlear condyles. The radial (*r*, fig. 6) of these, when entire, would have been the most prominent of the two.

The metacarpal (Pl. 71, figs. 1 and 2) which supported the fourth digit has a proximal articular surface of a more definite triangular figure (Pl. 67, fig. 5); the anconal border (*a*) being the longest, and the angle between the radial (*r*) and ulnar (*u*) borders being rounded off. The articular surface is continued upon both these sides of the shaft, but further for the articulation with the mid-metacarpal than for that with the fifth.

The anconal surface (Pl. 71, fig. 1) of the shaft is almost flat and lies more on the plane of that surface of the entire metacarpus than in the marginal metacarpal above described (fig. 3). The radial and ulnar surfaces of fig. 1 converge palmad to the narrow convex palmar surface which forms the rounded angle of the proximal triangular tract (ib., fig. 6, *ur*, *p*). Both radial and ulnar surfaces of the shaft are concave lengthwise and across (ib., fig. 2, *r*). The transverse concavity of the distal articular surface is feebly indicated, and the bifid character of the joint is scarcely marked, though fractured surfaces suggest that a pair of low palmar prominences may have been broken away; but the joint is much less trochlear than in the first metacarpal (ib., fig. 6).

A metacarpal of similar type to the preceding has suffered too great mutilation of both ends to serve for profitable description; it is not a corresponding metacarpal of the right fore-foot, but may be either a second or third, though from the slight superiority of length I should judge it to have been the second metacarpal of the same left fore-foot as the subjects of Pl. 71 belonged to.

A metacarpal with a subtriedral shaft, and an oblique twist at its basal half through an extension radiad of the radial angle, upon which angle the flat proximal articular surface has extended for the metacarpal on that side, is evidently a fifth metacarpal bone.

The distal surface (Pl. 67, fig. 6) is oblong and almost flat save where it becomes convex on being continued from the basal upon the radial surface; it is feebly concave transversely at its middle half, but this is not continued, deepening, so as to divide the palmar part of the joint into a pair of trochlear condyles. The length of this metacarpal is 5 inches 9 lines; the breadth of the proximal end is 4 inches; of the distal end 3 inches 2 lines; the breadth of the middle of the shaft is 2 inches 3 lines.

The largest of the proximal phalanges extracted gives a length of 5 inches 5 lines; with a breadth of the proximal end of 4 inches, and a breadth of the distal end of 3 inches 7 lines. The breadth of the middle of the shaft is 3 inches; and this seems not to have been more than 1 inch 7 lines in ancono-thenal diameter, but the thenal surface is partially crushed in. The anconal surface is smooth and flat save toward the expanded articular ends. The proximal surface, moderately concave, appears to have been adapted to a distal articular surface of the simple character of the metacarpal last described (Pl. 67, fig. 6). The distal surface of the phalanx is moderately trochlear, *i. e.*, with a feeble transverse concavity along its middle half; it is strongly convex throughout in the opposite (anconothenal) direction. The size of this proximal phalanx indicates it to have belonged to one of the larger middle digits.

Of the instructive terminal phalanges, the most entire forms the subject of figs. 4 and 5 of Pl. 68. The small proportion preserved of the thin, smooth, punctate, articular surface shows a partial depression at *b*, fig. 4; but the bone is so slightly abraded where that smooth crust is wanting as to afford a fairly true figure of its general shape, which is almost flat, with a feeble sinuosity. The anconal border (*a*) is most produced; consequently that surface of the phalanx is longest; but it is little more than half as long as it is broad. The thenal surface is made concave lengthwise by the thenal production of the terminal lobes of the distal end (Pl. 68, fig. 5). There is no appearance of these being articular. I regard them as the free termination of a last or ungual phalanx, and to show a modification of that end like the terminal phalanx of the second toe in *Iguanodon* (‘*Dinosauria*,’ Pl. 48, *i i*, 3).

Not any of the fragments of phalanges suggested a structure for supporting a terminal claw, such as exists in *Megalosaurus*. The fore-foot of *Omosaurus*, as represented by the bones above described, was a short, broad, massive member, relating chiefly to progressive motion, and suggests the huge species, if not, like *Iguanodon*, phytophagous, to have been a mixed feeder.

Ilium.—The mass of matrix with the portion of the skeleton of *Omosaurus* figured in Pl. 72, reduced to one ninth of the natural size, includes, with the sacrum, both the iliac bones and a large portion of the right ischium. The left ischium and both pubic bones, one of which was almost entire (Pl. 73, figs. 4 and 5), were wrought out of the block in the course of exposing the rest of the pelvis upon which they were lying dislocated.

The length of the ilium is 3 feet 5 inches; that of the antacetabular portion is 1 foot

9 inches; that of the postacetabular portion is 9 inches, but the end of this is broken off on both sides; the breadth of the superacetabular portion is 7 inches; the length of the acetabulum is 1 foot 1 inch; the breadth of ditto is 9 inches; the extent of the unwalled part of the cavity is 7 inches.

Besides the pelvis and the detached vertebræ above noted the right femur and probably the shaft of the fibula were left in the mass in the relative positions exposed in Pl. 72, in which the pelvis is seen from the hæmal (ventral or lower) aspect.

The ilium (ib., 62—62″) is an oblong, broad, and thick bone, anchylosed by a neuromedial tract, two feet in length, to the expanded ends of the five sacral ribs (ib., *pl.* I—V).

The hæmal surface is divided into an acetabular tract (62), an antacetabular production (62′) of greater antero-posterior extent, and a shorter postacetabular production (62″).

The lateral or external surface, or superacetabular tract, extends neurad and outward to terminate in a thick rugged convex border (*r*), which is continued forward, subsiding as a ridge upon the outer or neural surface of the antacetabular prolongation, (62′); the ridge is lost about nine inches from the fore-end of the antacetabular plate, and gives a triedral form to this part of the ischium. The ridge, continued from *r*, answers to that in the ilium of the *Iguanodon* noted at p. 287.* But the proportions of the antacetabular and postacetabular productions are reversed in the Kimmeridgian as compared with the Wealden Dinosaur.†

The length of the antacetabular part of the ilium in *Scelidosaurus* more resembles that in *Omosaurus*, but it is narrower and extended more in the axis of the trunk, or is less inclined outward. The corresponding part of the ilium in *Cetiosaurus* resembles in breadth that of *Omosaurus*. In this the acetabular cavity (62) is thirteen inches in longitudinal, nine inches in transverse extent. Its outer and hinder border subsides at *e*, and the cavity is continued upon the superacetabular surface of *r*, the break in the boundary being somewhat analogous to the cleft in the more developed border of the Mammalian acetabulum for the passage of vessels to the intra-acetabular synovial mass. The lower or hæmal part of the cavity is completed by the ischium (ib., 63), which articulates syndesmotically with the surface (*b*, *e*). There is no surface for the articulation of a pubis with the ilium, the *Omosaurus* in this respect corresponding with the *Crocodilia*. In the breadth also of the ilium as compared with the length that bone of *Omosaurus* comes nearer to the Crocodilian than to the Lacertian type.

And, again, in the extent to which the ilium is prolonged in front of the acetabulum the Crocodiles‡ depart less from the Dinosaurs than do the Lizards. In *Lacerta*

* "The outer surface is divided into two facets by a strong longitudinal ridge, for the attachment of some of the powerful muscles of the hind limb."

† Compare '*Dinosauria*,' Pl. 10, fig. 1, 62′ and 62″, with Pl. 72.

‡ Cuvier, 'Ossemens Fossiles,' 4to, 1824, vol. v, pl. iv, fig. 15, *a*.

nilotica, e.g., the ilium is prolonged in front of the acetabulum to an extent equalling only that of the acetabular excavation of the same bone.

Ischium.—This bone (Pl. 72, 63, and Pl. 73, figs. 1—3) offers the structural type of that in *Chelonia* and certain *Lacertilia* (*Uromastyx, e.g.*, Pl. 73, figs. 8 and 9, 63), in its 'tuberosity' or posterior process (*c*); but, in its slenderness or relation of breadth to length, it exceeds that in any Lacertian or other (to me) known forms of existing Reptile.

Of the iliac articular end of the right ischium but little is exhibited, the bone (63, Pl. 72) having been pressed forward and behind the part of the acetabulum from which it has been dislocated. The process (*c*) answering to that so marked in *Uromastyx*, in the more perfect left ischium (Pl. 73, fig. 8), comes off nearer the articular end than in the Lizard. The rest of the bone is simply styliform and straight, having no process crossing, as in Birds, the obturator interspace between ischium and pubis. The smooth concavity on the under or hæmal surface of the expanded end, articulating with the ilium, contributes about a fourth part of the cavity for the head of the femur. The end of the process (*c*) is rough, thickened, of an elongate subtriedral form, $2\frac{1}{2}$ inches by 1 inch; the opposite or fore-end of the expansion has a rough syndesmotic surface for the attachment of a similarly roughened end of the pubis. The breadth of the ischium, including these processes, is 13 inches; from this part the bone quickly contracts to a narrow plate. The hind margin of this plate (ib., fig. 1, *e*) is moderately thick and rounded, whence the bone thins off to an edge in front (ib., *f*). The hæmal surface is flat or feebly concave, transversely, and is smooth (Pl. 73, fig. 1). The upper or neural surface is, transversly, rather convex, save where it extends upon the acetabular part (*a*, *d*), and here it is rather concave. The body of the bone gradually contracts to a breadth of $2\frac{1}{2}$ inches; it then slightly expands to its symphysial end (ib., *g*, and fig. 3), which has a breadth of 4 inches, with a thickness of 2 inches. Restoring a part wanting between the preserved body of the ischium and the symphysial end, to the extent indicated by the dotted lines in Pl. 73, fig. 1, the total length of this pelvic bone in *Omosaurus* would be 2 feet 6 inches.

Pubis.—This bone (Pl. 73, figs. 4—7) presents the type of the pubis in Lacertians (ib., figs. 8 and 9) in the pectineal process (*c*), and the perforation (*d*), but adheres to the Crocodilian type in presenting one articular surface only at the proximal end (*a*) for the ischium, and (seemingly) contributing no share to the acetabular cavity. A Chelonian character is shown in the length of the bone between the head (*a*) and the process (*c*).

The articular end (*a*) has been better preserved than the corresponding one of the left ischium (ib., fig. 1). It presents a narrow, elongate, synchondrosal, roughish facet, 6 inches in length, 1 inch 7 lines in breadth, with a moderate convexity in the long axis (ib., fig. 6). The posthumous abrasion of the articular surface checks an absolute statement as to the precise configuration of this ischio-pubic joint in the recent Omosaur, but

the proportion, if any, contributed by the pubis to the acetabulum must have been very small, for no trace of such appears.

The pubis as it recedes from this joint gradually narrows to a breadth of 3 inches 4 lines, then more rapidly expands to form the perforated pectineal plate (*c*). This plate or process becomes, as in Lizards and Tortoises, thickened and tuberous at its free prominent border, which describes a bold convexity before subsiding into the slender continuation of the pubis (*e, f*). The margin of *c* continued thereto by the dotted line, in figs. 4 and 5, is a fractured one; and the angle of the border (*e*) to which the dotted line is continued shows also fracture; the extension of bone along that line is inferential. Proximad of such fracture the anterior border of the pubis is entire and sharp, a continuation of that which partly circumscribes the oblique pectineal hole or channel (*d*).

From the pectineal expansion the pubis contracts to a breadth of 2 inches, then expands to its symphysial end (*g*), which, when entire, must have had a breadth of from 5 to 6 inches. The abraded surface (ib., fig. 7) gives a fuller ellipse than that of the ischium (ib., fig. 3), but, as in that bone, indicates a symphysial junction with the opposite pubis. The hind border of the pubis (*f*) is rounded and thicker than the fore border (*e*).

The neural surface (ib., fig. 5) is feebly canaliculate lengthwise in part of its extent, and this character is shown, though still more feebly, in the pubis of *Uromastyx* (fig. 9, 64). But the accentuation of this surface in the broader half of the pubis of *Omosaurus*, as shown in fig. 5, is due to crushing and fracture seemingly in relation to the original prominence of the part of the pectineal process (*c*, fig. 5), which has been pressed to flatness with slight concavity.

I conclude from the length of both ischium and pubis that they diverged from each other, viz., from their outer to their inner or symphysial ends, at an angle nearer that in Crocodilians than in Lacertians. There is no evidence or indication that these hæmapophyses were disposed otherwise than in the rest of the Reptilian class, meeting, each pair, at the medial line, with a space between ischia and pubes, answering to a common and uninterrupted obturatorial vacuity. This space, in *Dicynodon*, is obliterated by continuous ossification.

The length of the pubis in *Omosaurus* is 3 feet 6 inches, the extreme breadth is 9 inches; the least breadth of the pre-pectineal part (*b*) is 3 inches 6 lines; the extreme thickness of this part is 1 inch 3 lines.

Femur.—To the right of the pelvis lies the femur of the same side, with the hinder surface exposed (Pl. 72, 65). The head (*a*) of the bone is at a distance of 1 foot 8 inches from its socket (*e*) and a little posterior to it. The distal end lies exterior to and a few inches in advance of the right ilium. The terminal articular surfaces of the shaft are, to some extent, worn away, but sufficient remains to show that the chief convexity or head (*a*) projected some inches within the inner longitudinal border of the shaft, the proximal surface sloping slightly distad to the rough convex angle,

representing a trochanter (*b*), from which a thick rough ridge is continued, gradually subsiding upon the shaft.

The breadth of the proximal end of the bone is 1 foot 1 inch; at 1 foot distance from that end the shaft is contracted to a breadth of 8 inches, and at its middle part to one of 6 inches. Notwithstanding the posthumous pressure which has shattered this part of the crust of the femur, one may infer that the shaft was naturally subcompressed from before backward.

At three fourths of the distance from the head of the bone the shaft again begins to expand, attaining at the distal end a breadth of $13\frac{1}{2}$ inches. There is a distinct oblong protuberance (*c*) at the inner and back part of the shaft, 1 foot 6 inches beyond the head, corresponding to that more developed prominence which has received the name of 'third trochanter' in *Iguanodon* and *Scelidosaurus*. There is also evidence of a longitudinal ridge (*d*) continued from the back part of the trochanter, about 9 inches down the shaft, inclining toward the middle of the hinder surface.

The popliteal cavity (*e*) is moderately concave, chiefly transversely through the backward production of the outer condyle (*g*). This is of less breadth posteriorly than the inner condyle (*f*) but is more convex as well as more prominent. The outward extension of the femur (*h*) beyond this prominence is somewhat unusual.

Tibia.—This bone is represented by its proximal end and three fourths of the shaft (Pl. 74, figs. 3—6). The shaft is more slender in proportion to the head than in *Hylæo-* or *Scelido- saurus*, and yields a full subelliptic section (ib., fig. 6). Part of the articular surface for the inner femoral condyle may be recognised at *a*, and that for the outer condyle at *b*, fig. 3, Pl. 74. A procnemial plate (*c*), with a base of 7 inches in extent, projects forward 4 inches beyond the articular part of the head of the bone. As wrought out of the matrix this plate shows a sharper free border than probably was natural; its obtusely rounded summit, *d*, has retained its condition as an epiphysis. The diameter of the head of the tibia in the direction of the procnemial prominence (*a*, *c*, fig. 5) is 11 inches. The preserved longitudinal extent of the tibia is 2 feet. The two diameters of the fracture (*f*, fig. 3) are 4 inches 6 lines and 3 inches 6 lines. The indication of a medullary cavity at the fracture (*f*) are hardly so definite as in fig. 6, and such as it is, the cavity was short; for at the fracture (*e*) the corresponding central portion of the shaft shows an open osseous tissue with wide chondrosal interspaces.

In the obliquely fractured and partly crushed end of the shaft the trace of medullary cavity has disappeared. The osseous tissue of the rest of the shaft is compact. Notwithstanding the degree of crushing, the beginning expansion in the tibio-fibular direction and of contraction or flattening in the rotulo-popliteal direction is unmistakable, and has led me to conclude that the distal, more flattened end of the bone is that which is wanting in the present specimen.

OTHER PARTS OF HIND LIMB.—Exterior to the right femur and overlain by it is the shaft or slender part of a bone, 16 inches in length and 3 inches in breadth; it bears the proportion of a fibula to the tibia above described.

FIG. 1.

Metatarsals of Omosaurus ?

No recognisable tarsal, or other bone of the hind-foot, has been detected in the indurated matrix forming the bed of the Omosaur. But Professor Phillips, in his instructive 'Geology of Oxford,' states,* "Three metatarsals in the Oxford Museum, apparently of *Megalosaurus*, lying in their original apposition, have been obtained from the Kimmeridge Clay of Swindon and seem to indicate a tridactyle foot (diagram lxviii)." I subjoin a copy of the cut of these bones (Fig. 1), deeming it more probable that they belonged to the genus of Dinosaur now known to have left remains in that formation and locality, than to the *Megalosaurus*, of which no indubitable evidence has yet been obtained from Kimmeridge Clay, either at Swindon or elsewhere. A is an outline of the proximal, B of the distal, ends.

These bones exemplify the 'leptopodal' character of the Dinosaurian foot, due to the reduction of thickness or breadth by suppression of two of the toes, and a consequent departure from the short, thick, or broad 'pachypodal' character of the pentadactyle hind foot of the existing and extinct terrestrial *Chelonia* and of some *Lacertia*.

DERMAL SPINE.—One osseous spine ('*Dinosauria*,' Pl. 74, figs. 1 and 2; Pl. 75, figs. 2 and 3) has been successfully wrought out of the matrix; but though a close search was made for other evidences of a dermo-skeleton none have been found.

The spine in question is 1 foot $6\frac{1}{2}$ inches in length, and not more of the tip seems to be wanting than might extend this dimension to 1 foot 7 inches, or, at most, 1 foot 8 inches; the long diameter of its base (Pl. 75, fig. 2) is 5 inches; the shaft gradually tapers to a point. The spine is rounded and slightly compressed; the narrower diameter is shown in Plate 74, fig. 1, the greater breadth in ib., fig. 2. The surface, smoothest toward the base, becomes slightly broken by fine longitudinal, *quasi* fibrous, markings; and this sculpturing becomes coarser as the spine contracts. At every part may be seen small orifices, apparently vascular; few in number along the basal two thirds, but more frequent near the point. These indicate a periosteum in relation to the supply of a horny sheath, of which we have here the petrified bony core. The texture of the osseous substance is dense (Pl. 75, fig. 3).

The base is obliquely truncate, with a boldly sculptured border, broadly and deeply notched as if for strong ligamentous attachments, the whole basal surface being coarsely roughened; it is also channelled, seemingly, by two vessels entering the substance of the

* 8vo, 1871, p. 215.

spine, one, perhaps, an artery, the other a vein (Pl. 75, fig. 2). The spine is traversed by a central medullary or chondrosal canal, in diameter one third that of the smaller diameter of the spine (ib., fig. 3). The rough imperforate part of the base, like its coarse periphery, suggests adaptation to syndesmotic junction with some other bone. But with what part of the frame?

There is a want of symmetry at the obliquely truncate base, which suggests this spine to have been one of a pair.

In *Scelidosaurus* the dermo-neural spines at the neck and fore-part of the back are similarly 'somewhat unsymmetrical in form,' showing a parial arrangement along that part of the trunk, but they are succeeded by symmetrical dermo-neural spines having a medial position along the rest of the trunk and tail.

The osseous spines, probably dermo-neural, of *Hylæosaurus*, show a length in proportion to the adjacent vertebral centrums somewhat exceeding the present spine of *Omosaurus;* they are, likewise, obliquely truncate at the base, and unsymmetrical in shape, but in a greater degree; and they are much more compressed (' *Dinosauria*,' Pl. 37, *d*).

In the Hylæosaurian specimen in the British Museum, which turned the scale in favour of the dermo-neural hypothesis, an irregular angular depression is described and figured at the base; and this repeats, though single, the pair of depressions or canals above noted, and reputed vascular, in the base of the spine of *Omosaurus*. The low, obtuse, thick ridge girting the base of the spine in *Hylæosaurus* is, however, simple, unnotched; the provision for attachment of the spine, in *Omosaurus*, betokens a greater power of resistance against displacement. The superior strength of the spine, due to its full elliptical shape in transverse section, suggests its application as a weapon to be wielded for attack rather than as one of a merely defensive palisade of spines.

Considering the number of vertebræ—dorsal, sacral, caudal—which have been recovered in more or less completeness from the intractable mass of some tons weight, including the rest of the above described recovered parts of the skeleton of the Omosaur, it might reasonably be expected that, had the trunk and tail been defended by dermal spines, as in *Scelidosaurus* and *Hylæosaurus*, especially by spines similar in number and arrangement to the dermal ridged scutes in the more Crocodilian Dinosaur of the Lias, evidences of such appendages to the trunk-skeleton should have been found in the grave of the great Kimmeridgian dragon.

But we are, now, not limited to the head, the trunk, or the tail in quest of positions of armour afforded by dermal bones to extinct members of the Reptilian class.

In the great Mantellian *Iguanodon*, or at least in the male of that species, a pair of spines supported by unsymmetrical conical bony cores were wielded for offensive action by the fore-limbs (p. 508, Pls. 46, 47). The form and proportions of the Iguanodontal carpal spine, especially in its degree of compression, are more like those of the spine in *Omosaurus* than are any of the dorsal spines in *Hylæosaurus*. True, the conical spine-

core in *Iguanodon* is shorter in proportion to its basal breadth than is the problematical spine in *Omosaurus.*

It is significant of the nature of this one unsymmetrical osseous spine that the bones of one of the fore limbs, the left, and that limb only, should have been preserved, and in a more complete state than any other part or limb of the present remarkable Dinosaurian framework; the spine in question lay not far from the radius and carpus.

Two spines of similar form to that of *Omosaurus*, but of larger size, were discovered near each other in a pit of Kimmeridge clay at Wootton Bassett, Wiltshire, and formed part of the well-known collection of William Cunnington, Esq., F.G.S., now in the British Museum. Whatever contiguous bones may have been dug out of the same part of the pit were not preserved. These two spines form a pair, and resemble each other as much as would the right and left radius, or the right and left ulna, of the same Dinosaur. They differ from the (carpal?) spines of *Omosaurus* in having a sharp edge, which in a transverse section, like that of fig. 4, Pl. 77, would terminate one end of the long diameter of the ellipse. The lethal power of the weapon was augmented by this character of the sword added to that of the pike. The degree of obliquity, the coarse marginal notching, and vascular perforations of the base, are as in *Omosaurus;* but the expansion is greater, yielding dimensions of 8 inches and $6\frac{1}{2}$ inches in long and short diameters; there is a slight submedial ridge dividing the basal articular surface into two shallow channels. The long diameter of the shaft, four inches beyond the least produced part of the base, is $3\frac{1}{2}$ inches, being nearly the same as in *Omosaurus.* The edge of the spine is along the same line as the most produced part of the base. The shaft has a central cavity, as in *Omosaurus.* Should these prove to be a pair of carpal spines they indicate a species of Dinosaur distinct from *Omosaurus armatus.* They will be further described and figured in a subsequent part of the present work.

ORDER *DINOSAURIA.*

Genus—CETIOSAURUS.*

Species—*Cetiosaurus longus,* Ow. (Plate 76, and Woodcuts 2—11).

UNTIL a comparatively recent period the generic or family characters of the great extinct Cetiosauroid Reptiles were founded on a few scattered bones of the trunk and limbs.† The texture of these fossils mainly differentiated them from the corresponding vertebræ and limb-bones of previously determined genera or species of Saurians. No

* Gr. κήτειος, cetaceous; σαῦρος, Lizard; "Report on British Fossil Reptiles," Part ii, in 'Reports of the British Association,' &c., for the year 1841; also 'Proceedings of the Geological Society of London' or June, 1841 (vol. iii, p. 457).

† *Ante,* p. 405; provisionally referred to the order *Crocodilia.*

portion of the skull, not one tooth, had been discovered so associated with Cetiosaurian bones, at the date of my "Reports on British Fossil Reptiles,"* as to throw any additional light on the ordinal affinities of the new genus. I had not, then, grounds for dissociating it from the Crocodilian group or order. The grand accession of evidences of the osseous framework of one of the species† added to the original Collection of Buckland, preserved in his Museum at Oxford, by his eminent successor, Professor Phillips, F.R.S., by whom they have been instructively elucidated in his excellent work on the 'Geology of Oxford,'‡ has proportionally advanced the means of determining the ordinal relations and affinities of the genus. The inferences which may be drawn in favour of the Dinosaurian characters of the sacrum will be subsequently discussed. But the demonstration of the sacral characters of the more recently discovered Cetiosauroid genus *Omosaurus* adds to the grounds for referring the type-species of Cetiosaur to the Dinosaurian group of Reptilia.

It is characteristic of the accidents that attend the quest and acquisition of the remains of extinct Vertebrates, that skull, jaws, and teeth should have escaped the careful operations to which we are indebted for the present means of restoring both *Cetiosaurus longus* and *Omosaurus armatus*. Of the former reptile a single doubtful and mutilated tooth was all that Prof. Phillips could refer with any degree of probability to that species.

That the side-pits of saurian vertebræ have no essential relation to largely cancellated, pseudo-pneumatic structure of the bones is shown by their presence in the anterior trunk-vertebræ of the genus for which the uniformly close though coarse osseous texture, as in the whale tribe, suggested the generic name *Cetiosaurus*.

The first indication of this type of Saurian was, however, afforded by an inspection of a limb-bone, submitted to me by Dr. Buckland in 1838, when I was engaged in collecting materials for my 'Report' to the British Association "On the Fossil Reptilia of Great Britain." Buckland had referred to this fossil in his 'Bridgewater Treatise,' 1st edit., 1836, in the following terms:—"There is in the Oxford Museum an ulna from the Great Oolite of Enstone" (Enslow probably meant), "near Woodstock, Oxon., which was examined by Cuvier and pronounced to be cetaceous; and also a portion of a very large rib, apparently of a whale, from the same locality."

This limb-bone I could not match with any then known to me in the Cetaceous order. Yet, save a thin compact outer crust, the osseous structure was, where exposed, like that in the humerus of a Whale or Grampus; there was no medullary cavity. In shape the resemblance, though remote, seemed nearest to that of the outer metatarsal of a Monitor Lizard.§

* 'Reports of the British Association for the Advancement of Science' for the years 1839 and 1841.

† "*Cetiosaurus longus*," Ib., 'Report' of 1841, p. 101; *ante*, p. 413.

‡ 8vo, 1871.

§ Prof. Phillips, who had obtained, in 1870, from the Great Oolite at Enslow, the three metatarsals

Shortly after I was able to differentiate certain saurian vertebræ from those ascribed to the genera *Iguanodon*, *Hylæosaurus*, *Megalosaurus*, and *Poikilopleuron*, not only by superiority of size, but by differences in form, proportions, and structure.* The latter character applied, more especially, to these huge unknown fossil bones in the comparison with *Poikilopleuron*, in the vertebræ of which four-footed reptile ossification is incomplete and large chondrosal vacuities are left in the substance of the centrum, which, in the fossils, become filled with spar.†

From the similarity of texture of the vertebræ of the new genus of Saurian so indicated to that in the limb-bone from "Blechingdon," Enslow, I suggested that it might belong to *Cetiosaurus*.‡ The cetaceous hypothesis of the huge Oolitic Vertebrate was thereupon abandoned, and my determination was adopted in the second edition of the 'Bridgewater Treatise,' and also by Lyell, who gives a reduced cut of the fossil in his 'Manual of Geology,' ch. xx.

In 1848 Dr. Buckland informed me of the discovery of a femur, 4 feet 3 inches in length, which, from the correspondence of its texture with that of the metatarsal from Blechingdon, and also with that of some fragmentary long bones from Blisworth, Northamptonshire, I referred to the genus *Cetiosaurus*, and to the species from the Great Oolite called *Cetiosaurus longus*.§

More recently (1868—70) a considerable proportion of the skeleton was discovered in the quarries of the Great Oolite of Enslow Rocks at Kirtlington Station, eight miles north of Oxford, the bones of which more nearly approached in size to the type specimen of *Cetiosaurus longus*.‖ I, therefore, visited Oxford for the purpose of studying these remains.

Such of the trunk-vertebræ as were sufficiently entire appeared to have come from the fore part of that region, and showed the opisthocœlian character of those vertebræ as in certain Dinosaurs.

In the best preserved anterior dorsal vertebra the parapophysis, short but large in vertical extent, shows remains of the articular surface for the head of the rib. The diapophysis, supported by a strong buttress-like ridge, is directed upward and outward at an angle of 45° with the neural spine. The distance between the articular surface for

of each hind foot of a *Cetiosaurus*, wherewith he was able to compare the above fossil long bone, "incomplete at both extremities," considers the determination of it as a metatarsal of large size to be 'probably true.'—'Geology of Oxford,' &c., 8vo, 1871, p. 285.

* 'Proceedings of the Geological Society of London,' June, 1841, *loc. cit.*

† The chief of these cavities, being in the centre of the vertebræ, was termed 'medullary' (loc. cit., p. 459); but I have since had reason to conclude that it was occupied in the living Saurian by unossified chondrine.

‡ 'Report,' *ut supra*, p. 101.

§ Ib., ib. Also *ante*, p. 413.

‖ "Vertebræ 8, 9, and 11 inches in diameter," "monstrous ribs," "femora upwards of 5 feet in length."—'Athenæum,' April 2nd, 1870.

the 'tubercle' and that for the 'head' of the rib is ten inches, which indicates the extent of the 'neck' of the rib at this fore part of the thorax. The neural spine is strengthened by lateral buttress-like ridges rising from the neural platform; it is of a massive quadrate form and seems to have terminated obtusely. The zygapophyses are supported by buttress-like vertical ridges.* All the characters of this massive vertebra bespeak the great strength of the back-bone of the enormous saurian. The total vertical extent of the above vertebra, which is incomplete at the wider part of the centrum, is 2 feet 4 inches; the breadth at the diapophyses is 1 foot 6 inches.

The vertebra which is the subject of '*Dinosauria*,' Pl. 76, from a hinder position of the trunk than the above-described, exemplifies the cetiosaurian characters of texture (fig. 2, *p*) also of a contracted antero-posterior extent of the neural arch as it rises from the centrum,† and of a partial subsidence of the anterior ball. This vertebra has been crushed and fractured; the right side is pressed obliquely backward for an inch or so beyond the left side, so that the length of the centrum, measured as it has been squeezed out of shape, exaggerates its original or natural longitudinal diameter. This would not exceed, according to my estimate eight inches. The vertical diameter of the centrum has also been pressed down beyond its original extent. I estimate the ball or fore part at $6\frac{1}{2}$ inches, the cup behind at 7 inches, in height. The neural arch, as in the type-vertebræ of *Cetiosaurus longus*,‡ is retained in anchylosed union with the centrum to the extent shown in Plate 76, viz., eight inches.

A vertically grooved median ridge appears to commence at the back part of the base of the spine. This process is wanting; it probably would have added a foot to the present vertical extent of the vertebra, which is sixteen inches. Minor projecting parts have been equally broken away, and, as usual, lost in the quarrying or extricating operations. Such fractures occur on both sides of the prominent rim of the hinder cup of the centrum (as at *p*, fig. 2, Pl. 76). The singularly naturally compressed upper and middle part of the centrum (ib. *f*) underlying the neural canal and forming a vertical plate or medial wall of bone, three to four inches in height, and but six lines to eight lines in thickness, has been in part broken away, exposing that canal. The fore and hind outlets of the neural canal are squeezed into a narrow, vertically lengthened, oval shape (ib., fig. 2, *n*).

The neurapophysis rises by two buttress-like columns (ib., fig. 1, *n′ n*, *n*) which converge as they ascend and overarch the lateral depression *f*. The base of the neural arch is coextensive with the centrum, save in so far as the anterior ball may have projected

* "On *Cetiosaurus* from Oolitic Formations," 'Proc. Geol. Soc.,' 1841, l. c., p. 459. *Cetiosaurus longus* is defined as in the 'Report,' and distinguished from the *Cetiosaurus brevis* of the Wealden Formations, pp. 101, 102, which will probably prove to be referable to a distinct cetiosauroid genus.

† In the account, illustrated by woodcuts, given by Phillips in his excellent 'Geology of Oxford,' pp. 246—294, a vertebra, supposed to be lumbar, the subject of the diagram lxxxviii, p. 257, has assigned to it the following admeasurement:—"Greatest length from front to back (crushed) 4·6 in." I have found no trunk-vertebræ of the *Cetiosaurus* from the Kirtlington Oolite so short as this.

‡ "In all these vertebræ the neurapophyses are anchylosed to the centrum," &c.—'Report,' p. 102.

beyond; but the neurapophysis soon shows, as it rises, the 'short antero-posterior extent,' which is among the characteristics of the genus. One advantage of the fractures, which must otherwise have been got by sections, is the demonstration of the cetiosaurian texture of the bone (Pl. 76, fig. 2, *p*). The resemblance of this close but somewhat coarse osseous tissue to that of cetaceous bone, especially in the larger Whales, and which seems to characterise the whole skeleton of the present genus of gigantic saurians, might well excuse the idea that the huge long bone first observed was cetaceous.

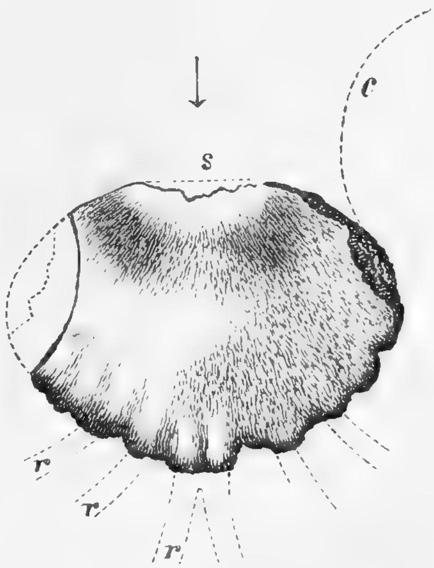
The unbroken surface of the vertebra has a fine fibroid character; the interrupted lines affecting a longitudinal course on the centrum and a vertical one on the neurapophysis. How far any exposure of the arch at the base of the spine may have formed a part answering to the 'platform' in the antecedent vertebra, and as in most Dinosaurs, the broken state of the specimens does not allow of determination.

Near the borders of the articular ends of the centrum, which are more or less rubbed away, stronger sculpturing is indicated, as if in relation to ligamentous attachments.

The lower border of the lateral depression, *f*, is more obtuse, less definite, than in *Bothriospondylus* (Pl. 63, fig. 1); the vertical convexity of the side of the centrum changes in *Cetiosaurus* more gradually into the concavity of the depression.

The sternum of *Cetiosaurus longus* is a transversely elliptical plate with an almost flat, slightly undulate upper or inner surface (fig. 2); 19 inches broad, 15 inches long, 1 inch to $1\frac{1}{2}$ inch thick, increasing to $2\frac{1}{4}$ inches at the coracoid articular surfaces, though, probably, the entire expanse of the border here is not preserved. The hind border shows prominences for the attachment of three pairs of sternal ribs, *r*, *r*, the hindmost pair in contact, as in *Monitor niloticus*.

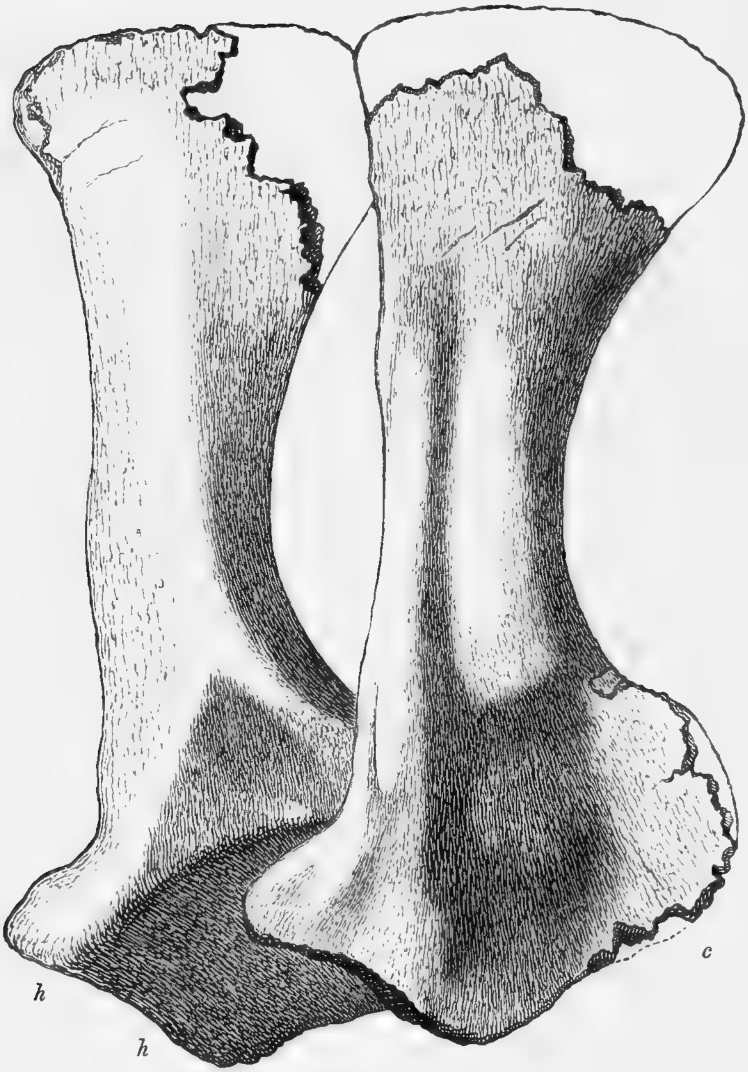
Fig. 2.



Sternum, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., 'Geol. of Oxford,' part of diagr. xcviii, p. 268.)

In this Lizard the sternum has a rhomboidal form, with a low median ridge on the outer or under surface, a deep hollow on the opposite surface, and considerable thickening of the articulations for the coracoids. Were these bones fully ossified in that Lizard they would correspond in breadth with those of *Cetiosaurus;* there are, however, two tracts retaining the primitive sclerous state, and an antero-medial part which has not gone beyond that of gristle, in the coracoid of the recent saurian. We have, therefore, in *Cetiosaurus*, as in some other ancient

Fig. 3.

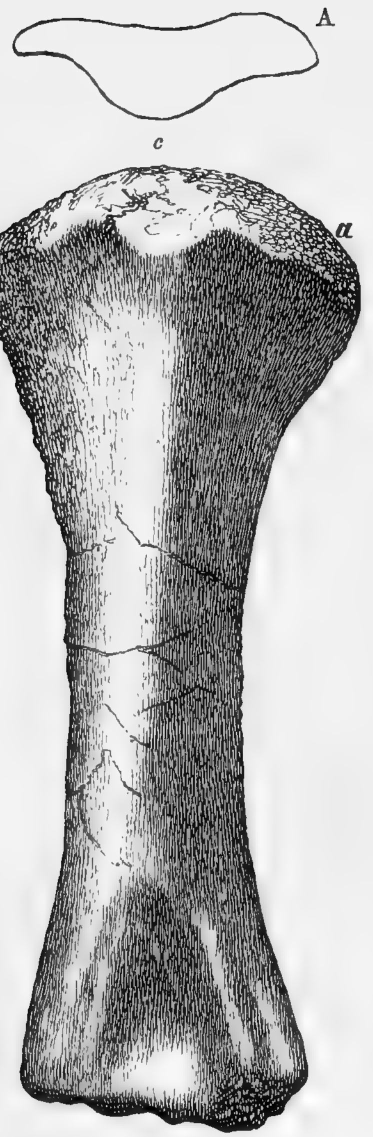


Scapula, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., diagr. xcix, p. 270.)

saurians, notably of the order *Dinosauria*, a degree of lacertian structure combined with a crocodilian advance of vertebral and concomitant cardiac and pulmonic structures.

The scapula of *Cetiosaurus* (fig. 3) is more crocodilian than lacertian in its proportions. It is an elongate plate, expanded at both ends, but most so and most abruptly at the articulations for the coracoid, *c*, and humerus, *h*, *h*. The more gradual

FIG. 4.



Right.

FIG. 5.

Right.

Humerus, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., diagr. c., p. 272.)

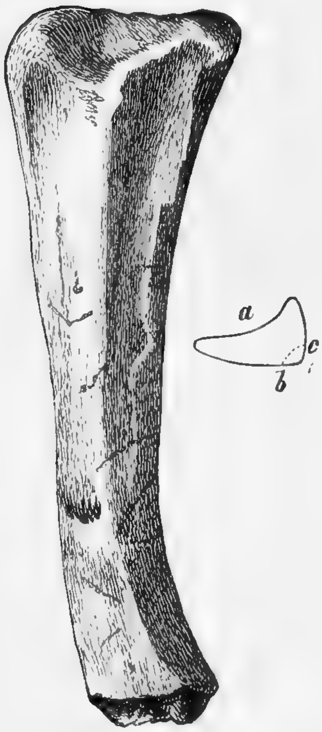
expansion of the base or free extremity is chiefly due to the hinder border, and this describes a concavity, while the fore border is nearly straight. The outer surface (left) is slightly depressed lengthwise behind a longitudinal ridge near to and parallel with the anterior border. The inner surface (right) has a longitudinal rise near the middle,

which bifurcates to strengthen the humeral and coracoid surfaces, and to add to the thickening of the articular end of the bone. PHILLIPS notes the modification of structure of the basal three inches of the blade, indicative of coarse or partial ossification of an original cartilaginous superscapula, the proportions of which element would thus be more crocodilian than lacertian. The resemblance of the blade-bone of *Cetiosaurus* to that of *Scelidosaurus* has already been noted. But the production of the anterior or humeral angle of the articular end is somewhat greater, approaching that in *Hylæosaurus*. The length of the scapula of *Cetiosaurus longus* is 4 feet 6 inches, the breadth of the articular end is 2 feet 2 inches, the least breadth of the body of the bone 10 inches.

The humerus of *Cetiosaurus* seems far from exhibiting the outstanding plates and ridges for muscular attachments, such as we see in *Omosaurus* (Pl. 70, figs. 1 and 2) and the larger existing lizards (*Hydrosaurus, Monitor*), which run swiftly on land; they are even more feebly indicated than in the Crocodiles, but much of this inferiority may be due to posthumous injury and abrasion in the present huge fossils.

The head of the humerus, fig. 4, *a*, A, is an elongate, semi-oval, narrow convexity, broadest at the middle, which projects toward the hinder or anconal surface of the bone, as in Lizards and Crocodiles; the degree of the projection is shown in the outline of the proximal end of the bone, at *c*, fig. 4, A.

FIG. 6.



Ulna, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., diagr. ciii, p. 275.)

The ridge from the radial side of the proximal third of the shaft (fig. 5, *b*), answering to the 'pectoral' or 'deltoidal' one in the Mammals, commences, as in the Monitors, near the head, not, as in the Crocodiles, abruptly at some distance below; it has suffered abrasion in the Kirtlington specimen, yet seems not to have stood out in the same relative degree as in *Omosaurus*, or as in the Monitor, in which, as in the Crocodile, it is bent toward the fore or palmar side of the bone.

The shaft of the humerus in *Cetiosaurus* is subcompressed, subtrihedral, through an obtusely angular longitudinal low ridge or prominence, on the anconal side (fig. 4), continued from below the head to near the distal end, inclining toward the radial side. There is no trace of the distal ridge from that border of the shaft which, in Monitors, answers to the 'supinator' ridge in Mammals (Pl. 70, fig. 6, *e*). The more prominent of the two distal articular convexities, that, viz., for the head of the radius, is feebly indicated; the back part of the convexity for the ulna is traceable at the worn distal end of the bone (fig. 5, *a'*).

The pectoral and supinator ridges are still more feebly in-

dicated in the humerus of a small or young *Cetiosaurus*, figured by Phillips at p. 273, Diag. CI.

The length of the Kirtlington humerus (op. cit.), figs. 4 and 5, is 4 feet $3\frac{1}{2}$ inches; extreme breadth of the proximal end 1 foot 8 inches; of the distal end 1 foot 3 inches; diameters at the middle of the shaft 8 inches by 4 inches.

The proportion of the ulna (fig. 6) to the humerus appears to be nearly that in the Monitor. The shaft is more distinctly three-sided, the anconal surface being strengthened by a median longitudinal rising or ridge not present in *Monitor*. As in this Lizard the palmar concavity excavates the whole of the upper half of that surface of the shaft except at the outer and inner ridged boundaries. The margin toward the radius is concave, the opposite one nearly straight, feebly convex. Both ends of the ulna of the Kirtlington Cetiosaur are wanting; it measures in this state upwards of 3 feet in length. In the section, fig. 5, *a*, the palmar side, *a*, is 12 inches across; the facet, *b*, of the anconal side is 11 inches; the narrower facet of the same side, *c*, is 7 inches. No recognisable bones of the fore foot of the *Cetiosaurus longus* appear as yet to have been discovered; but the proportions of the known parts of the fore limbs are such as to make it more likely that they took their share in a quadrupedal mode of progression than that they were borne aloft, with the trunk, on the hind legs like the folded wings of a bird.

The first almost entire femur of *Cetiosaurus longus* was obtained mainly through the personal care and supervision of Hugh E. Strickland, M.A, then (1848) of Merton College, from one of the divisions or thin bands of the 'Great Oolite' underlying the Cornbrash near Enslow Bridge, north of Oxford. The length of this femur is 4 feet 3 inches.

In 1868 the femur of a larger individual of *Cetiosaurus*, and in 1870 the other bones of the same individual, here described and referred to the species *Cetiosaurus longus*, were discovered in the same quarries, close to the railway-station for Kirtlington, eight miles north of Oxford. Professor Phillips having notice of the first discovery took the requisite steps, with his wonted energy, to prosecute the quest and secure for his science the evidences of the monster dragon.

The thigh-bone, first come upon, "was found to be lying on a freshly bared surface of the Great Oolite, nearly in the line of a natural fissure, and covered by the laminated clay and thin oolitic bands which there occupy the place assigned to the Bradford Clay of Wiltshire." *

This bone was 5 feet 4 inches in length. In the course of the quarrying works the opposite femur and many other bones of the same skeleton were brought to light. The majority of these "did not actually touch the Oolite, still less were embedded in it, though single exceptions occurred of each circumstance."

* 'Geology of Oxford,' p. 247-8.

"The strata covering the solid Oolite were thus noted, Marcn 21st, 1870:

"Thin skerry beds of Forest-marble and shaly clay.

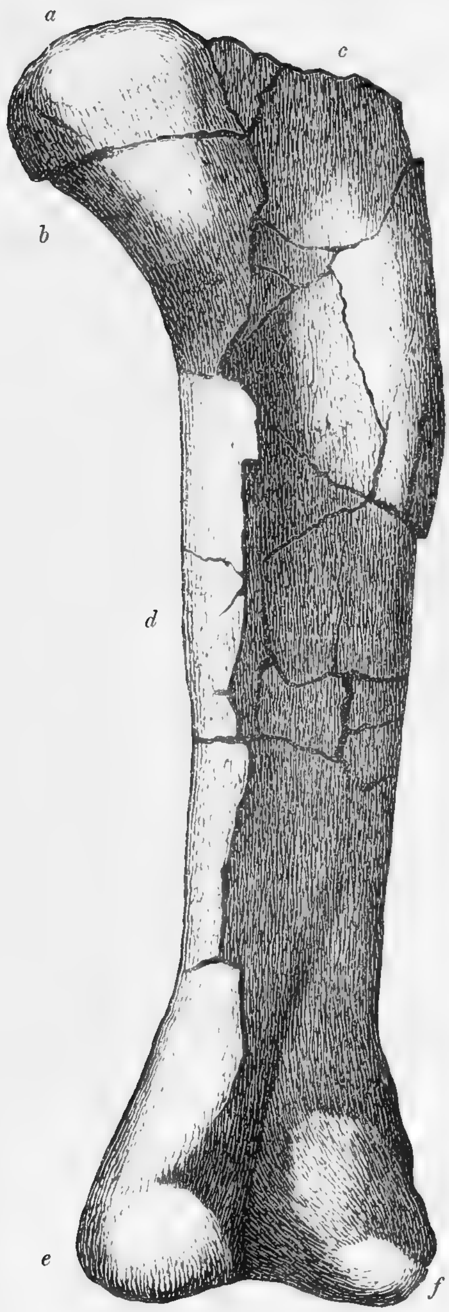
	Ft.	in.
"Band of white calcareous concretions and clay . .	0	10
"Blue and greenish clay with white calcareous spots, and selenite .	2	7
"Brown, yellow, and grey layers, argillaceous, sandy, and oolitic .	1	4
"Grey and argillaceous bed, with selenite . . .	0	2
"Grey and greenish bed loosely oolitic, with *Terebratula maxillata*, *Avicula*, *Astarte*	0	8
"Clay and loosely aggregated oolitic parts, with selenite and abundance of carbonized wood, some shells, and most of the bones .	1	6
"Clay below	0	6

"Great Oolite with undulated and waterworn surface. The two lower bands 'die out' to the southward, and there some of the bones came in contact with the rock, and others were engaged in it." Phillips, ut supra, p. 251.

The most striking of the remains here discovered was the fellow femur (right) of the one (left) found in the previous year. The anterior surface of the latter (left) is shown in cut, fig. 7. It is 5 feet 4 inches in length, the diameter of the middle of the shaft is 1 foot, that across the condyles 1 foot 5 inches. The shaft is naturally subcompressed, but the flattening has been exaggerated by posthumous pressure to which the closely cancellated texture of the interior of the shaft has yielded, with fracture of parts of the denser outer crust; but there is no sufficient indication of the head, *a*, having been pressed so as to project inward, from any original disposition of that prominence forward, such as characterises the femur in modern Crocodiles and Lizards. The relation of the head to the shaft of the bone is thus more mammalian than saurian in the gigantic Cetiosaur. But the 'neck,' *b*, is short, or almost nil; the trochanterian angle, *c*, not produced above the level of the neck or head. The trace of any prominence for muscular attachment at the inner part of the shaft, *d*, is feeble; by no means such as appears in *Scelidosaurus* or *Iguanodon*. The distal end expands to the condyles, *e*, *f*, but in a minor degree than in the Monitor.

The cut, fig. 8, shows the postero-external surface of the right tibia of *Cetiosaurus longus*. The prominence, *a*, is that which receives the outer condyle of the femur; the border, *b*, in the view of the proximal end, gives the contour of the antero-internal part, which is rather flatter than in *Monitor*; *c* shows the production above the procnemial ridge at the fore part of the bone; *d* is the part which was articulated to the distal epiphysis supporting the outer malleolus. The proportions of the tibia to the femur are

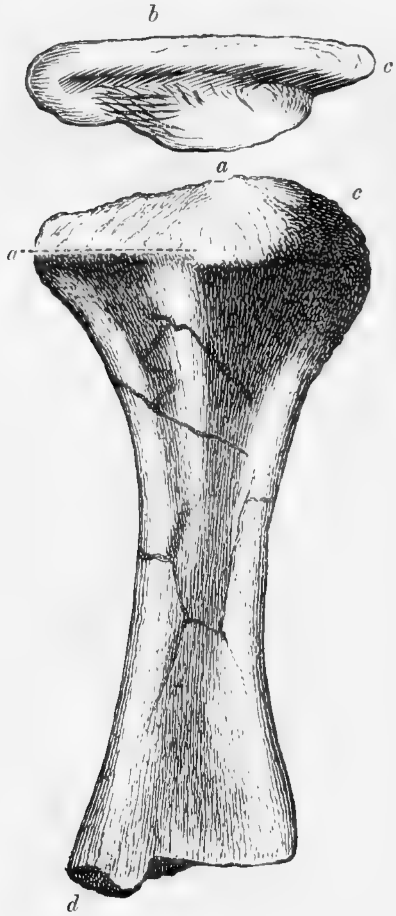
FIG. 7.



Femur, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., cviii, p. 281.)

less than in Monitors or Crocodiles; the length of the bone (fig. 8, *a*, *d*) is 3 feet 10 inches; the breadth of the end adapted to the femur (fig. 7) is 1 foot 7 inches; that of the distal end is 1 foot.

FIG. 8.



Tibia, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., part of diagr. cix, p. 282.)

As Professor Phillips remarks, "the terminal surfaces are strongly marked by the pitted adherence of cartilage, ... which gives the appearance of deficient epiphyses." *

In a full-grown *Monitor niloticus* the distal epiphysis, which affords the articular

* P. 282-3. He adopts an idea that the convex part of the anterior surface of the distal portion of the shaft of the tibia in the Crocodile is the homologue of the ascending process of the astragalus of *Megalosaurus*, but "separated from its base and anchylosed to the tibia; while in *Megalosaurus* the connection remains, and the ascending process is not joined by synostosis to the tibia" (op. cit., p. 283). *Scelidosaurus* instructively exemplifies the homology of the distal epiphysis of the tibia in Dinosaurs with that in the Monitor and the Bird, and demonstrates the separate existence of the bone answering to the astragalus, &c., in both Crocodiles and Lizards, but which is not ossified in the tarsus of Birds (p. 499, cut, fig. 4).

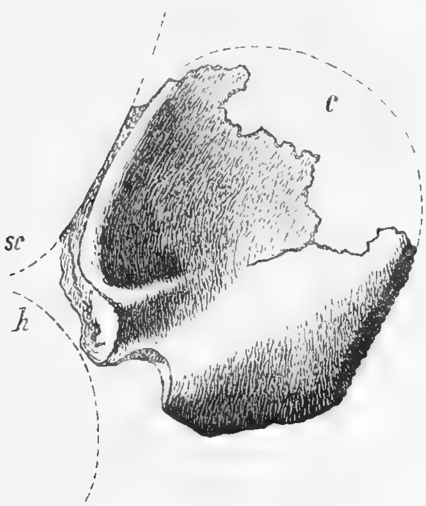
surface to the astragalus, is unanchylosed, the line of suture closely resembling that in the distal end of the present fossil.

Of the foot-bones, "three metatarsals of each foot were secured." The largest appeared to be the first or innermost, the slenderest the third or outermost of the series. "Perhaps there were only three metatarsals, since the specimens we possess exhibit opposite pairs of three and no more" (Phillips, op. cit., p. 285).

That these bones are homologous with those determined as the second, third, and fourth of the pentadactyle foot in *Scelidosaurus* and *Iguanodon* I deem more probable than that they answered to the metatarsals of the first, second, and third digits in *Crocodilus*.

If a first or a fifth digit existed in the hind foot of *Cetiosaurus*, their shortness or rudimental condition may have prevented their recognition.

Fig. 9.



Coracoid, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., part of diagr. xcviii, p. 268.)

In the description of the osseous characters then known of the largest species of Whale-Lizard, I remarked:

"These enormous *Cetiosauri* may be presumed to have been of aquatic and, most probably, of marine habits, on the evidence of the coarse cancellous tissue of the long bones which show no trace of medullary cavity." *

In reference to their affinities:

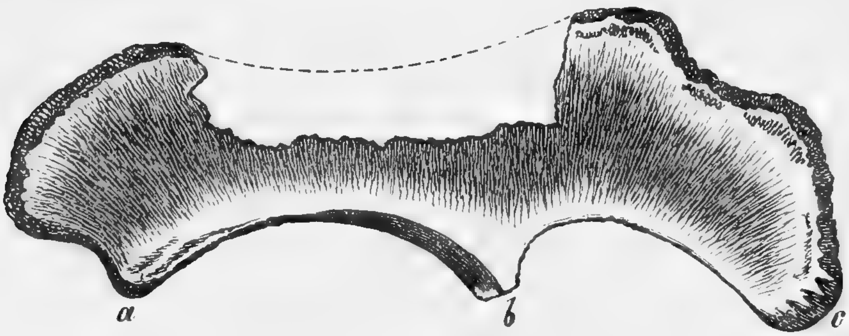
"In the great expanse of the coracoid [fig. 9] and pubic bones, as compared with the Teleosaur and Crocodiles, the gigantic Saurians in question manifested their closer affinity to the *Enaliosauria*" †—closer, that is, than the Teleosaurs or Crocodiles show; but "their essential adherence to the Crocodilian type is marked by the form of the long

* 'Report,' *ut supra*, p. 102. † Ib., ib.

bones of the extremities, especially of the metatarsals: and, above all, by the toes being terminated by strong claws." Here, in 1842, the clawless character of the limbs of Plesio- and Ichthyo-sauri was the dominant idea, to the exclusion of the then novel group of *Dinosauria*, "characterised by a large sacrum composed of five anchylosed vertebræ of unusual construction," &c.*

The question to be determined in respect to *Cetiosaurus* is the admissibility of the genus by the sacral character to the Dinosaurian order. This character, in 1842, I put in the van, relating as it does, physiologically, to terrestrial progression more after the manner of Mammalian quadrupeds than of existing four-footed Saurians, whether Crocodiles or Lizards; an extent of the trunk being thereby transmitted, through a co-extensive ilium, upon hind limbs, the chief bones of which are 'medullary' in *Dinosauria*.

Fig. 10.



Ilium, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., cv, p. 278.)

The ilium (fig. 10) of the *Cetiosaurus longus*, from the Kirtlington quarry, is estimated by Phillips as probably equal to six vertebræ. He writes:

"The extreme length of one (ilium) is 42, of the other 45 inches, probably equal to six vertebræ,"† —such sacral vertebræ being estimated each at a little over 7 inches in length.

These vertebræ are briefly noticed as follows:—"Several bones of this portion are in the collection, but there is great difficulty in so placing them as to acquire a just notion of the structure or to present a satisfactory drawing. In some degree it (the sacrum) must have approached that of *Hylæosaurus*." ‡ I found a nearer approach to the sacrum in *Scelidosaurus*.

In either comparison the length of the sacrum is not to be estimated as equal to that of the ilium. In *Scelidosaurus, e.g.*, in which the number of sacral vertebræ is 'four,' the parts of the ilium anterior and posterior to the sacro-iliac symphysis, or surface of junction with such vertebræ, give to that pelvic bone almost twice the length of the sacrum. The length of this part of the spine in *Scelidosaurus* is 10 inches, whilst that of the ilium is

* 'Report,' *ut supra*, p. 102. † Op. cit., p. 278. ‡ Op. cit., pp. 257-8.

18 inches, "a part, apparently a small one, being wanting from both extremities" of the iliac bone. But, on this basis, we may allow to the ilium of 45 inches length a sacrum of 24 inches, or one of four vertebræ, each 6 inches in length. It is not probable that a saurian with iliac bones between 3 and 4 feet in length, and thigh-bones between 5 and 6 feet in length, would have a sacrum reduced to the crocodilian formula of two vertebræ.

Admitting, then, that more numerous sacrals, such as the Tortoises show, are not the sole and may not be the chief character of *Dinosauria*, and that the generalisation signified by that term is a passing one, denoting a step in the progress of knowledge of the extinct *Reptilia;* and supposing that it should be now limited to saurian genera, combining, with four or more sacrals, the alternating or interlocking arrangement of the autogenous vertebral elements—as in *Bothriospondylus, Megalosaurus, Iguanodon, Hylæosaurus, Omosaurus*—the question to be solved is:—"Does such arrangement characterise the sacrum of *Cetiosaurus?*" Have we, in the absence of any certain or definite knowledge of the cranial and dental characters of the genus, grounds for determining its ordinal relations to the Dinosaurs, Crocodiles, Sauropterygians, Ichthyopterygians, Lacertians, &c.? I am disposed to wait for such additional evidence, admitting, meanwhile, the faculty of terrestrial progression in a superior degree to that of the amphibious Crocodiles; nevertheless, the habitual element of the Cetiosaur may have been, and I believe to have been, the waters of a sea or estuary. And I may here repeat the remark on the initial evidence of the species:—"The main organ of swimming is shown, by the strength and texture and vertical compression of the caudal vertebræ, to have been a broad vertical tail; and the webbed feet, probably, were used only partially, in regulating the course of the swimmer, as in the puny *Amblyrhynchus* of the Galapagos Islands, the sole known example of a saurian of marine habits at the present period."*

In fact, to the characters of the caudal vertebræ of *Cetiosaurus longus* known to me at the date of the above-quoted 'Report,' viz.—"post-zygapophyses represented by hollow pits," "slight concavity of both articular ends of the centrum, moderate compression of the sides between the expanded ends, which are subcircular,† the under surface concave lengthwise, marked by parial articular surfaces, showing the hæmal arches to be articulate therewith over the vertebral interspaces"‡—the discovery of the grand proportion of the skeleton of the individual at the Enslow quarries adds a demonstration that the hæmal arch in an anterior caudal vertebra (fig. 11) attained a length of 1 foot 2 inches; and that the neural spine "probably rose twelve inches above the canal,"§ giving a total vertical extent of upwards of a yard to such anterior caudal. The vertebræ probably exceeded in this dimension at the middle of the tail.

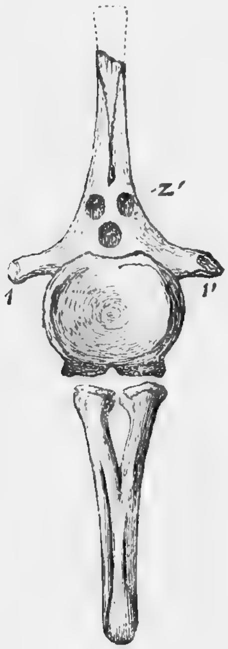
The modifications of the caudal vertebræ in parts of the tail of *Cetiosaurus longus*, as exemplified by specimens from the Great Oolite described and figured by Phillips ('Geology of Oxford,' 8vo, 1871), are similar to those in the instructively preserved

* 'Report,' &c., p. 102. † Ib., pp. 101, 102. ‡ 'Ib.,' &c., pp. 101, 102. § Phillips, op. cit., p. 259.

Dinosaur from the Dorsetshire Lias (*Scelidosaurus Harrisonii*, Ow.), now in the British Museum.

The broad subquadrate coracoid, with rounded angles, of the *Cetiosaurus longus* from the Enslow quarries (fig. 9) repeats the characters of that bone in the type of the species ('Report,' p. 102). In the Oxford giant the bone measures "from the glenoid cavity to the extremity near the scapular margin (incomplete) 18 inches; if complete, probably 20; breadth between scapular and sternal margins, 18·5 inches; greatest thickness 5·0." (Phillips, op. cit., pp. 270, 271.)

Fig. 11.



Caudal vertebra, *Cetiosaurus longus*, $\frac{1}{10}$th nat. size. (Phps., lxxxix, p. 259.)

The scapula of *Cetiosaurus* resembles that in *Scelidosaurus*, with rather less concavity of the anterior border, and rather more concavity of the posterior one. It surpasses the humerus in length in a minor degree than in *Scelidosaurus*, and in a still less degree than in *Iguanodon*.

In the characters of the dermo-skeleton *Cetiosaurus* would seem not to agree with *Scelidosaurus*. It is very improbable, if there had been such agreement, that not any skin-scutes or spines should be shown in connection with the large proportion of the skeleton of one and the same individual brought to light on the excavated oolite of Enslow Rocks at Kirtlington.*

The same negative evidence in all the various finds of fossil remains on which the genus was based suggested, in 1841, the idea that the tegument of *Cetiosaurus* might be smooth, or unarmed, as in *Cetacea* and *Enaliosauria*. But, as has been shown in antecedent contributions to the 'History of British Fossil Reptiles,' a new interest will attach itself to the future occurrence of an osseous spine, seemingly dermal, in contiguity with the parts of the fore-limb which were wanting, or not discovered, in the Kirtlington example of *Cetiosaurus longus*.

In *Scelidosaurus* the number of vertebræ between the skull and sacrum is twenty-three or twenty-four; in *Iguanodon* the same region includes more than seventeen vertebræ: in this genus there are five sacral vertebræ: in *Scelidosaurus* four. In no Dinosaur has the number of caudal vertebræ been so satisfactorily or approximately demonstrated as in *Scelidosaurus*. Thirty-five of these vertebræ were obtained in consecutive articular association in the individual fossil skeleton in the British Museum. If we allow the Cetiosaur, on this analogy, twenty-four vertebræ between the skull and sacrum, averaging 5 inches each in length, and add an inch for the intervertebral connective tissues, we get a total length of trunk at 12 feet. Four sacral vertebræ would add two feet. Taking the number of the caudal vertebræ at that shown in *Scelidosaurus*,

* Phillips, op. cit., diagr. lxxxiv, p. 250.

and the reduction of length in the ten terminal ones not to be more than is there shown, the length of the tail of *Cetiosaurus longus* may be set down at 17 feet. Thus we get an approximative idea of the length of this Cetiosaur, *minus* the head, as 31 feet. The fortunate discovery of the skull or lower jaw, or a mandibular ramus, would supply the ground for completing an idea of the size of the whole animal. As the femur of *Cetiosaurus longus* found in 1868 in the Enslow locality exceeded in size that found in 1848, so the subject of cut, fig. 7, may ultimately prove not to represent the extreme size attained by individuals of the species; and the length of 7 inches shown by the typical caudals would found an estimate of 35 or 36 feet for the length of trunk and tail of *Cetiosaurus longus*.

As evidence of this species have now reached me from four counties—Yorkshire, Northamptonshire, Buckinghamshire, and Oxfordshire—I submit that there is no case, according to the 'canons of zoological and botanical nomenclature' adopted by the 'British Association for the Advancement of Science,' * for suppressing the original name proposed by the discoverer of the species, and substituting one which is in ome degree misguiding. I would also plead for a retention of the orthography of the generic name.†

In my "Report on British Fossil Reptiles," Part ii,‡ I referred to the palæontologist, who, in 1869, was deservedly characterised as "that remarkable man whose recent death all who are interested in the progress of sound palæontology must deplore, Herman von Meyer,"§ in the following terms:—"In the tabular arrangement of extinct Saurians founded by M. Herm. v. Meyer on the development of their organs of motion, the *Megalosaurus* and *Iguanodon* are grouped together in Section B, with the following character:—Saurians with locomotive extremities like those of the bulky terrestrial Mammals: '(Saurier mit Gliedmassen ähnlich denen der schweren Landsaügethiere).'—*Palæologica*, p. 201. No other grounds are assigned for their separation from other Saurians." The needful quest of such grounds led to the discovery of characters which, with the essential unlikeness of the limb-bones of the two cited genera to those of any mammal, the inappropriateness of the name given to the family, and the evidence of the claims of the reptiles under review to form a group higher than a subordinate section of an order, weighed with me in defining the characters of such higher group, and to propose for it the name *Dinosauria*, a step which I still deem to be in the interests of "sound palæontology."

In support of the statement that "Prof. Owen, nine years afterwards, conferred a new name upon the group and attempted to give it a closer definition," Professor Huxley refers to Von Meyer's paper in the 'Isis' for 1830, admitting that he had "not verified

* 'Report of the Committee,' &c., for the year 1842.

† In framing this name the diphthong in κήτειος was dropped, as in 'pliocene,' 'miocene,' &c.

‡ 'Reports of the British Association,' 8vo., 1841, p. 103.

§ Prof. Huxley, 'Quarterly Journal of the Geological Society,' vol. xxvi, p. 32, 1870.

the citation," which his readers are left to conclude would have justified his definition of my work in relation to the *Pachypoda* of Von Meyer. A quotation could not, in fact, be given for the purpose Professor Huxley had in view. I therefore supply the omission, with the remark that the occasion of eulogizing a deceased palæontologist might be better improved than by making it a ground for reflecting on a living one.

In the 'Isis von Oken,' Band xxiii, Heft v, 1830, 4to, p. 518, HERMANN VON MEYER proposed the following distribution of Fossil Saurians according to the structure of their hind-limbs:—

" *Saurier mit Zehen, welche denen der lebenden am ersten noch entsprechen würden, und zwar*

" *a.* VIERZEHIGE.

" Rhacheosaurus, *H. v. Meyer.*
" Geosaurus, *Cuvier* (?).
" Teleosaurus, *Geoffroy* (?).
" Aeolodon, *H. v. Meyer.*
" Streptospondylus, *H. v. Meyer* (?).
" Metriorhynchus, *H. v. Meyer* (?).
" Macrospondylus, *H. v. Meyer* (?).
" Lepidosaurus, *H. v. Meyer* (?).
" Mastodonsaurus, *Jaeger* (?).

" *b.* FÜNFZEHIGE.

" Protorosaurus, *H. v. Meyer.*

" *Saurier mit flossenartigen Gliedmassen.*

" Ichthyosaurus, *Conybeare.*
" Plesiosaurus, *Conybeare.*
" Mosasaurus, *Conybeare.*
" Phytosaurus, *Jaeger* (?).
" Saurocephalus, *Harlan* (?).

" *Saurier mit Gliedmassen, ähnlich denen der schweren Landsäugethiere.*

" Megalosaurus, *Buckland.*
" Iguanodon, *Mantell.*

" *Saurier mit Flughaut.*

" Pterodactylus, *Cuvier.*"

The artificiality of these limb-characters has been pointed out, and has been accepted by the adoption, *e.g.*, of the ordinal distinction of the *Ichthyopterygia* from the *Sauropterygia*;* also of the order *Labyrinthodontia*,† as represented by *Mastodonsaurus* and *Phytosaurus*, which latter genera, included in v. Meyer's Section, *a*, 'Vierzehige,' are excluded from my order *Crocodilia*,‡ Whether any apology be necessary for the substitution of the latter term for a defined ordinal group including half of the representatives of von Meyer's "(*a*) Vierzehige" I leave to the judgment of unbiassed palæontologists, and proceed to cite the more definite ascription of taxonomical value to the groups above defined proposed by von Meyer, in his useful compilation called 'Palæologica,' 8vo, 1832. In this work the author prefixes to the class *Reptilien* (p. 101), as to that of *Mammalia* (p. 44), his division of such classes into Orders. Those which he adopts for the 'Reptilien' are—

"A. Chelonier.
B. Saurier.
C. Batrachier.
D. Ophidier."

This was the latest step in Palæontological ordinal classification with which I had to contrast the ideas of the Reptilian orders acquired during the researches of which the results were condensed in my 'Reports to the British Association' of 1840 and 1841.

Von Meyer's subdivision of the Saurian order is based, as in his previous sketch in the 'Isis,' upon the structure of the limbs:

"A. Saurier mit Zehen, ähnlich denen andern lebenden Sauriern und zwar I. Vierzehige. II. Fünfzehige."

"B. Saurier mit Gliedmassen ähnlich denen der schweren Landsaügethiere. 1. Megalosaurus, *Buckland*. 2. Iguanodon, *Mantell*."

"C. Saurier mit flossartigen Gliedmassen. 1. Ichthyosaurus, *König*. 2. Plesiosaurus, *Conybeare*. 3. Mosasaurus, *Conybeare*. *Streptospondylus*, H. v. M."

"D. Saurier mit Flughaut. Pterodactylus, *Cuvier*" (Op. cit., p. 201).

In the characters of his subordinate group B, Von Meyer (Ib., p. 210) condenses the descriptions and accepts the determinations, clavicle included, of Buckland and Mantell. There is no sign of his having examined any of the fossils on which these descriptions and determinations were based. He is struck with a resemblance of the metapodial bones of *Megalosaurus* in Buckland's plates with those of a hippopotamus; and with the size of one of these bones, "zweimal so breit als im Elephanten" of the *Iguanodon;* and may have deemed their feet, in like manner, to have been tetradactyle or pentadactyle.

* "On the Orders of Fossil and Recent Reptilia." From the 'Report of the British Association for the Advancement of Science' for 1859, 8vo, p. 159.

† Ib., p. 158.

‡ Ib., p. 164; and "Report on British Fossil Reptiles," op. cit. for 1841, 8vo, p. 63.

Such supposed character seems to have suggested to Von Meyer the name *Pachypoda*, which he subsequently applied to them, the proportions of the entire foot which would support such term being to him unknown.

The feet of Dinosaurs are, in fact, characterised by their narrowness or slenderness rather than by their breadth or thickness. The functional toes (hind feet), are, in the typical species of Von Meyer's *Pachypoda* reduced to three,* and do not exceed four (*Scelidosaurus*, e. g.) in any veritable member of the order. But had Von Meyer known the structure of the Dinosaurian foot, and it had been such as to have been truly defined by his 'family term,' this term must have given way to the "Pachypoda" proposed and accepted in 1821 for a similar group of *Mollusca;* as the same term, proposed for a family of *Coleoptera*, in 1840, had, in like obedience to taxonomic rules, sunk to the condition of a synonym under the law of priority, even when not affected by inapplicability of the name to its objects.†

Every specimen accessible in 1840, of Megalosaur, Iguanodon, Hylæosaur, having been examined and compared by me and the structure of the sacrum elucidated by observations on its development in birds,‡ vertebral characters, with dental ones, were substituted for those of the 'Family' above cited from the 'Isis' and 'Palæologica,' in the definition of the Order *Dinosauria*, quoted by Professor Huxley in his paper on this group.§ Of this definition the Professor asserts that "every character which is here added to von Meyer's diagnosis and description of his *Pachypoda* has failed to stand the test of critical investigation."‖ This statement is not accompanied with any evidence in its support, but by a suggestion that I had dealt unjustly with von Meyer in proposing the name and substituting the alleged inaccurate characters of the reptilian group *Dinosauria*. If I have to offer, in relation to the main end and aim of my labours, any remark which may seem critical, it will be accompanied by its grounds. Thus, in regard to the characters proposed by Professor Huxley for the Order *Dinosauria*—

"1. The dorsal vertebræ have amphicœlous or opisthocœlous centra. They are provided with capitular and tubercular transverse processes, the latter being much the longer" (loc. cit., p. 33).

If by 'amphicœlous' be meant 'biconcave,' as the term 'amphicœlian' has been applied to dorsal vertebræ of *Teleosaurus* ('*Crocodilia*,' Pl. 4, fig. 6) and of *Ichthyosaurus* (ib., fig. 7), no such vertebræ exist in the dorsal region of *Dinosauria*. The term 'amphiplatyan' would more truly express the configuration of the terminal articular

* *E. g. Hylæosaurus*, '*Dinosauria*,' Pl. 44; *Iguanodon*, ib., Pl. 45.

† *Pachypus* was given to a genus of *Coleoptera* in 1821; this, in like manner, reduced the *Pachypus* applied to a genus of mammals in 1839 to a synonym.

‡ 'Report on British Fossil Reptiles,' p. 106, 1841.

§ 'Quarterly Journal of the Geological Society,' vol. xxvi, p. 32, 1870.

‖ Ib., p. 33.

surfaces of the centrum in such dorsal vertebræ as are figured in '*Dinosauria,*' Pls. 65 and 66 of the present Work, and in corresponding vertebræ of *Iguanodon, Megalosaurus, Cetiosaurus, Hylæosaurus, Scelidosaurus, Bothriospondylus,* figured in previous plates. Not that the flatness of both ends of the centrum is absolute, but the deviation is slight and usually, when in the direction of concavity, confined to the hinder surface (as in the Dinosaurian vertebra, fig. 5, Pl. 4, above cited). Neither must it be supposed that the dorsal series may be 'amphicœlous' in one Dinosaur, or 'opisthocœlous' in another.

The centrum in some Dinosaurs, *Tapinocephalus,* e. g., shows at the middle of its flat articular surface a foramen one sixth the diameter of such surface. It is the base of a small conical cavity, the apex of which meets that of the cone of the opposite side,—a beaded remnant of the notochord appearing to have traversed the vertebral column. In other species examined by me certain cervical vertebræ and a few consecutive dorsal vertebræ are 'opisthocœlian,' *i. e.* have the 'ball' in front (fig. 4, Pl. 4, above cited); and the convexity, in certain of these, does not wholly subside until the lumbar region is reached. But whence did Professor Huxley derive his knowledge of the 'opisthocœlous' character in 'pachypodal Saurians'? If from the original definition of the Dinosaurian group,* that character, as there limited, seems to have stood the test of time.

The discoverers of the *Iguanodon* and *Megalosaurus* believed the ball to be behind, and von Meyer accepted this view of the conformity of the Dinosaurian with the Crocodilian dorsal centrums. In fact, the way to distinguish the fore from the hind end of a fossil saurian vertebra seems not to have been known to their describers until the test was defined in 1841. This knowledge, howsoever acquired by the writer of the "Character 1," here discussed, is applied by him in error to *Dinosauria:* in them the ball subsides at the beginning of the dorsal series.† I would further remark, that, as there are many modifications and characteristics of the so-called 'capitular transverse processes' and 'tubercular transverse processes,' in the varied series, including Dinosaurian, of vertebral structures, the advantage of single substantive terms is exemplified by the convenience and helpfulness to precise description which such terms afford, adjectively, in predicating of 'parapophysial' and 'diapophysial' modifications.

And if by 'capitular portion of the transverse process' Professor Huxley may mean 'parapophysis,' and by 'tubercular portion of the transverse process' 'diapophysis,'‡ I have then to object that the 'dorsal vertebræ' of *Omosaurus* do not all possess the two kinds of processes. In the subjects of Pls. 66 and 67 the head of the rib is received by a pit, not articulated to a 'capitular process.' The dorsal vertebræ, of which the ribs

* 'Report on Brit. Foss. Reptiles,' p. 91: "Remarks on Mantell's 'Fourth System' of Vertebræ from the Wealden."

† Ib., ib.

‡ 'Quarterly Journal of the Geological Society,' vol. xxxi, p. 426.

have not 'distinct capitula and tubercula,' have no 'capitular portions, or transverse processes;' in fewer words, no parapophyses.

In reference to Professor Huxley's "Character No. 2," I submit that a Saurian with sacral vertebræ reduced to two in number is not a Dinosaurian.

"3. The chevron bones are attached intervertebrally and their rami are united at their vertebral ends by a bar of bone."* This is a character of *Iguanodon*† and of *Scelidosaurus*,‡ but not of *Cetiosaurus*§ nor of *Omosaurus*,‖ "Char. 3" is one of a genus, not of the Order *Dinosauria*.

"5. The skull is modelled upon the Lacertian, not on the Crocodilian type." For the instances in which the Dinosaurian skull departs from the Lacertian, and approximates to the Crocodilian type, I refer to pp. 520—530, and '*Dinosauria*' (Pls. 50, 60), These instances confirm and add to the combination of Crocodilian with Lacertian characters, propounded, in 1841, as exemplifying the more generalised Saurian type of the extinct order *Dinosauria*.

"6. The teeth are not anchylosed to the jaws, and may be lodged in distinct sockets." They become anchylosed in *Hylæosaurus*, and the manifold modifications of the dental system in *Dinosauria* concur with those of the skull and jaws themselves in exemplifying the mixed or more generalised character of the group.¶

"7. There is no clavicle." This is probable from the crocodilian affinities shown in the skull and vertebræ; and the character founded on the bone, so called, in my early diagnosis of *Dinosauria*, must be suppressed: but I have not yet seen a specimen of a *Dinosaur* in which the scapular arch was shown in its natural condition and integrity.

Before continuing my remarks on some of the Professor's remaining twelve characters of *Dinosauria*, I would observe, in reference to comments upon the step taken of substituting that name of the Order for one of a Family which, for reasons above given, could not have stood in Taxonomy, that the further insight into the structure of *Mammalia* tersely expressed in the names and characters of the Orders in the 'Règne Animal' was gratefully accepted by all single-minded cultivators of Biology, although some of such orders were the same or nearly the same as those defined and otherwise named in the 'Systema Naturæ.' Cuvier was not deterred from fixing this additional step in the advance of Zoology by the opportunity it might open to an objector for charging him with unfairness or injustice to Linnæus; nor was Linnæus much moved by like remarks to which he was subjected by critics of that era in reference to his names for groups of plants more or less similarly defined, before him, by John Ray, and others.

* Ibid., vol. xxvi, p. 33.

† Monogr. 'Wealden Reptilia,' part ii, Pal. vol. for 1854, p. 15, t. viii. (*Iguanodon Mantelli*) ib. ib., t. i, *Iguanodon Foxii* (if this be not an immature specimen).

‡ Monogr. 'Fossil Dinosaur of the Lias,' Pal. vol. for 1860, p. 8, t. vii.

§ Phillips, 'Geol. of Oxford,' p. 259, fig. 2, 8vo, 1871.

‖ *Ante*, p. 55, pl. xvi.

¶ 'Odontography,' pp. 246—254, 269—272, pls. 62A, 70, 70A, 1840.

To return, however, to my proper task, more especially in reference to the affinities of the *Dinosauria*.

The first clue to the homology of the supposed clavicular bone of the Iguanodon* was given by Professor Leidy in the 'Proceedings of the Academy of Natural Sciences of Philadelphia,' December 14th, 1858. In the description there given of the fossil remains of a Reptile, which he calls '*Hadrosaurus*,' from the marl of New Jersey, which marl, from the affinity of this Reptile to the Iguanodon, he surmises may be of the Wealden or Green-sand period, Leidy finds, with the ilium, "a bone which I suspect to be the pubic, but which appears to correspond with that of the Maidstone *Iguanodon*, described as the clavicle" (p. 9). In a subsequent illustrated Monograph,† Leidy repeats his homology of the bone in question and notes—"an ilium and a supposed pubic bone, imperfect" (p. 71). Of the latter a figure is given ("Pl. VIII, fig. 13"), and the accomplished Author truly remarks :—"It bears a general resemblance to that indicated by Professor Owen and Dr. Mantell as the clavicle of the Iguanodon; but appears to me rather to resemble the pubic bone of the *Iguana* and *Cyclura* than the clavicle of the same animals."‡

Professor E. D. Cope, Corr. Sec. Academy of the Nat. Sciences, Philadelphia, communicated to the Academy, in 1867, a paper "On the Extinct Reptiles which approached the Birds," of which an 'Abstract' was given in the 'Proceedings of the Academy' for December of that year. In this 'Abstract' the Professor is reported as stating that "he was satisfied that the so-called clavicles of *Iguanodon* and other *Dinosauria* were pubes, having a position similar to those of Crocodilia."§ There is no reference, therein, to Professor Leidy, nor to the paper by Professor Huxley "On the Classification of Birds" which was published in the 'Proceedings of the Zoological Society,' 1867, p. 415.‖

In the lecture "On the Animals which are most nearly Intermediate between Birds and Reptiles," delivered by Professor Huxley at the Royal Institution of Great Britain, 7th February, 1868, he states:—"I hold it to be certain that these bones — the so-called 'clavicles'—belong to the pelvis and not to the shoulder-girdle, and I think it probable that they are ischia; but I do not deny that they may be pubes."

Thanks to the rapidity by which, through science, sea and land can now be traversed, we get the results of research by our American fellow-labourers within a fortnight, usually, after publication.

I have no doubt of the legitimacy of Professor Huxley's delusion—"I could not possibly have known anything about them when my 'Lecture' was delivered;" but

* 'Philos. Trans.,' p. 138, 1841.

† 'Cretaceous Reptiles of the United States,' p. 97, pl. viii, fig. 13: in the 'Smithsonian Contributions to Knowledge,' No. 192, vol. xiv, 4to, 1865.

‡ Op. cit., p. 97.

§ 'Proceedings of the Academy of Natural Sciences of Philadelphia,' p. 234, 8vo, 1867.

‖ See "Note," p. 24, in 'Quarterly Journal of the Geological Society of London,' vol. xxvi (1870).

the claimed originality of his views of problematical pelvic bones by no means called for any reflection on postal arrangements between Great Britain and the United States. The impossibility might merely mean an oversight which left the writer ignorant of both Cope's and Leidy's anticipations, as appears to have been the case with regard to von Meyer's paper in the 'Isis' of 1830.

In the "Further Evidence of the Affinity between the Dinosaurian Reptiles and Birds," with confirmatory testimony by Professor Phillips, of Oxford,* Professor Huxley adopts the ischial homology of the bone in question, and illustrates it by a diagram, "Fig. 3, *Dinosaur*," p. 27 (tom. cit.), in which the supposed "ischium" is directed from the acetabulum downward and backward, parallel with the pubis, with which it articulates by the process (*c*, figs. 4 and 5, in Plate XX, "*Omosaurus*"), so as to "interrupt the obturator space," and define, as in Birds, an anterior part of that space as an "obturator foramen" (loc. cit.).

To an advocate of the affinity of Dinosaurs to Birds and of the derivation of Birds from Dinosaurs, such determination of the bone in question gave great help, and the consequent diagram has been mainly subservient in gaining suffrages to the idea—I may term it sensational—of the kinship of the Iguanodon with the Cassowary, carried to the inference of a common bipedal mode of progression.

The value of the genus *Omosaurus*, as of every well-determined new Dinosaur, to the Palæontologist desirous, irrespective of foregone conclusions, to lay the basis of lasting views of affinity on fixed homologies, is here great. The bone, Pl. 72, 63, which completes the acetabulum, shows by the extent and position of its articulation with the ilium, from which it has been but slightly dislocated, that it is the ischium. The recovery of the parial bone to the extent shown in Pl. 73, fig. 1, shows that the shaft gives off no process; also that an extension of the iliac articular end beyond the acetabular surface of the ischium, and behind it, is the sole production, transverse to the axis of the bone, which can be homologised with a non-articular process in the ischia of other Vertebrates.

The ischia of *Omosaurus* being thus determined, the homology of the other pair of pelvic bones (Pl. 73, figs. 4 and 5), wrought out of the mass of matrix overlying the hæmal surface of the sacrum and ilia, was plain. They confirm the opinion of Professor Leidy as to the nature of the bone; and, so far as their dislocated condition indicated their natural direction, it supports the conclusion of Professor Cope that they had "a position similar to those in the *Crocodilia*," *i. e.*, directed forward and downward, as shown by Cuvier, in the 'Ossemens Fossiles,' tome v (1824), Pl. IV, fig. 15, *a*, Pl. V, fig. 6, and as exemplified in the diagram, Cut fig. 13, *p b*.

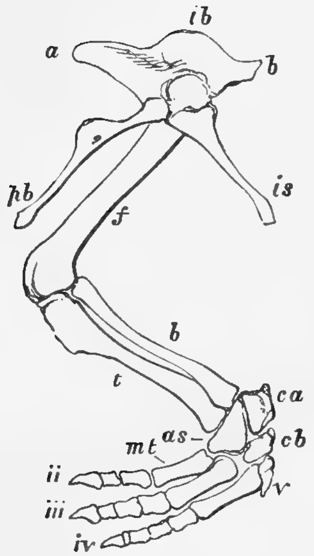
So much of the homological ground being thus cleared, we may pass to the question of the kinship or affinities it brings into view.

In birds, as a rule, the pubis is a long simple style without process (fig. 15, 'Bird'); the

* 'Quarterly Journal,' &c., tom. cit., p. 12.

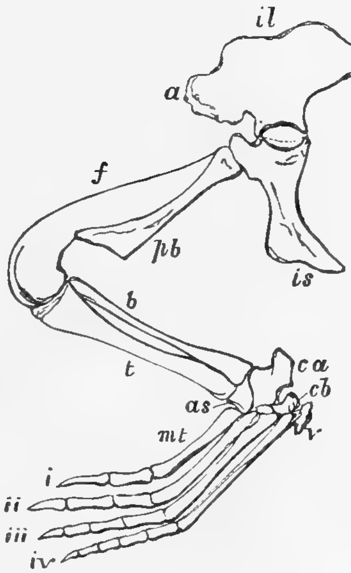
exceptions are chiefly seen in the wingless forms, *Apteryx*, e. g., and the Cassowary, in which latter bird the expanded acetabular and of the pubis projects forward, at *b*, beyond the joint, *a*, in a pointed form, about six lines in length. The proximal end of the pubis

Fig. 12.



Dinosaur.

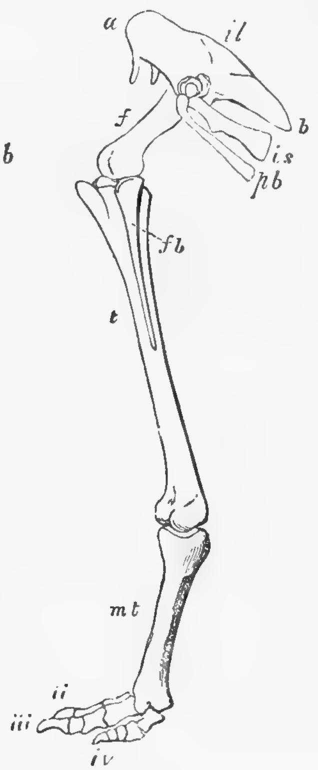
Fig. 13.



Crocodile.

Pelvic characters.

Fig. 14.



Dinornis.

enters into the formation of the acetabulum in all birds. The distal end terminates, in most birds, freely; in some it is anchylosed to the ischium; in the Ostrich it joins its fellow to form a symphysis pubis:* in all it is directed backward and downward.

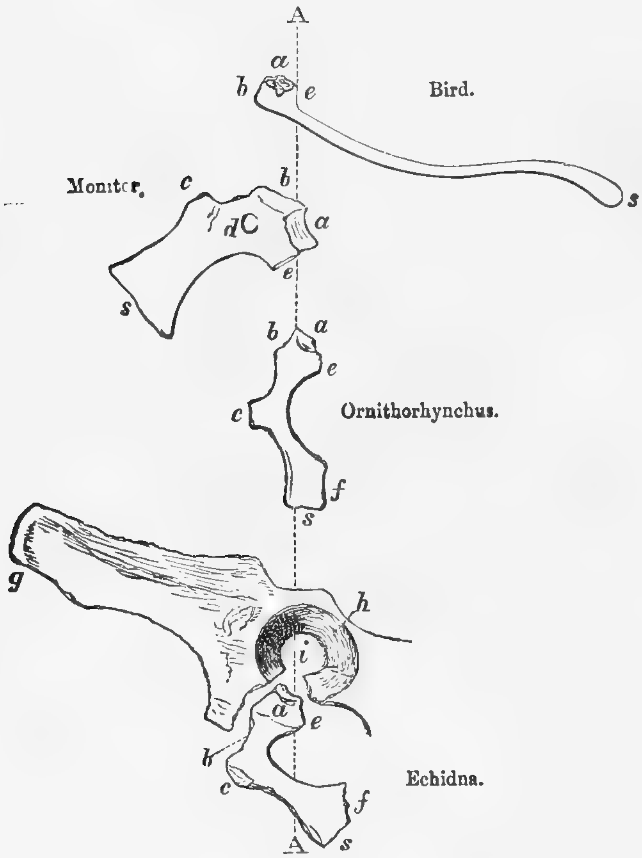
In the Monotremes the pubis (fig. 15, *Ornithorhynchus*) sends off from its fore part, about one third of its length from the acetabular end, *a*, a low and broad process, *c*, giving attachment to the outer part of the base of the marsupial bone. It joins its fellow at the expanded distal end, *s*, and joins at *f*, the corresponding end of the ischium,

* For other modifications, which, however, give no help in the present inquiry, see my 'Anatomy of Vertebrates,' vol. ii, pp. 35, 36.

thus dividing the obturator interspace into a pair of foramina. As in all mammals the bone is directed downward (hæmad) and a little backward.

In *Crocodilia* the pubis (fig. 13, *p b*), as in birds, is a simple style slightly expanded distally where it articulates with a cartilaginous abdominal sternum,* but it joins not

Fig. 15.



Modifications of pubis. The line A A traverses the corresponding part of the bone.

there, directly, either its fellow or the ischium. It contributes no part to the acetabulum, but is attached at its proximal end to an anteriorly produced part of the same end of the ischium (ib. *is*).

In *Chelonia* the pubis is remarkable for its breadth, due to its distal expansion; proximally it contributes to the acetabulum, articulating there with both ilium and ischium, and at or near half way to the distal end, it sends forward a broad and termi-

* 'Anat. of Vertebrates,' vol. i, p. 68, fig. 56, 5.

nally thick pectineal process;* it unites distally with its fellow, and in some species also, as in Monotremes, with the ischium, dividing the obturator space. The average proportions and common character of the pubis in *Lacertilia* are given in Cut, fig. 15, *Monitor;* the perforation *d* marks the closer resemblance to the Dinosaurian pubis (fig. 12, *pb*).

Notwithstanding the difference in the proportions of breadth and length, the pubis in *Iguanodon* and *Omosaurus*, in its essential characters, is more like that in the Tortoise than in any bird. But these proportions are among the most variable characters of the bone, and we have not far to seek in the Lacertian order before finding, as in *Uromastix*, a pubis combining with the pectineal process (Pl. 73, figs. 8 and 9, *b*), as slender a body thence continued as in the *Dinosauria*. Only, in *Omosaurus*, the proximal end of the bone seems not to contribute any share to the acetabular cavity; and, if this should be the case with other Dinosaurs, those extinct reptiles would combine, in their pelvis, as in some other parts of their skeleton, characters now restricted respectively to the Crocodilian and to certain members of the Lacertian groups of the class.

Thus, the ischium, in *Omosaurus*, has no other 'process' save the stunted homologue of the proximal extension supporting the pubis in *Crocodilia*.

In *Chelonia*, as in *Uromastix*, there is a distinct posterior process (marked *c* in figs 8 and 9, Pl. 73); but in certain Lizards (*Varanus niloticus*, e. g.)† it is reduced to a mere rudiment, and in the Chameleon it ceases to exist. Thus, the *Omosaurus* resembles the *Crocodilia* and some *Lacertilia* in the simplicity of its ischium, and markedly departs from the type of birds in respect to this bone.

But it is alleged that the ilium gives evidence of the avian affinity of Dinosaurs which we have now proved to be wanting in the rest of the pelvis. Among the "points of difference between any existing Reptile and any existing Bird," the following is put by Professor Huxley in the foreground.

"1. In the Reptile the ilium is not prolonged in front of the acetabulum." "In the bird the ilium is greatly prolonged in front of the acetabulum."

"Now, in all the *Dinosauria* which I have yet examined, the ilium extends far in front of the acetabulum."‡

To the first of these averments it needs only an elementary acquaintance with comparative osteology to reply, that in all Crocodilian Reptiles the ilium is prolonged in front of the acetabulum, and to an extent nearly equal to that in which it is produced behind the acetabulum. Reference to the well-known figure in the 'Ossemens Fossiles,' which I here reproduce (woodcut, fig. 13, *il*) exemplifies this fact: Cuvier has been careful to mark with the letter '*a*' the antacetabular part of the ilium which the advocate of the avian affinities and bipedal progression of the *Dinosauria* denies to it and to all other Reptiles, *Dinosauria*

* 'Anat. of Vertebrates,' vol. i, fig. 116, *h*.

† Cuvier, 'Ossemens Fossiles,' tom. cit., pl. xvii, fig. 40, *c*.

‡ 'Quarterly Journ. Geol. Soc.,' vol. xxvi, 1870, p. 26.

excepted. The ilium in Pterodactyles yields the same ground as that of Dinosaurs for predicating kinship with Birds.

The true characteristic of the ilium in *Dinosauria* is the distinction of the super-acetabular (Pl. 72, *r*) from the antacetabular (ib,. 62′) parts of the bone, with the anterior extension and subsidence, in some species, of the former upon the dorsal surface of the latter. This complexity of the ilium is wanting in both birds and pterodactyles.

As to the proportions of the ant- and post-acetabular extensions of the ilium, they vary in known *Dinosauria:* the post-acetabular production (Pl. 72, 62″) is shorter in *Omosaurus* than in *Scelidosaurus*, and is shorter in *Scelidosaurus* than in *Iguanodon*.

From the importance assigned by Professor Huxley to iliac characters, in the conclusion he advocates, a non-anatomical reader might infer not only that no other Reptiles, but that no other warm-blooded Vertebrates save Birds, had the ilium extended, as in Dinosaurs, far in front of the acetabulum.

And yet an impartial quest of the affinities of these huge terrestrial *Reptilia* would impel the seeker, having such end solely in view, so to extend his comparisons. In Mammals "the ilium is prolonged in front of the acetabulum," which, as in Reptiles, "is either wholly closed by bone or presents a fontanelle."

In the spiny Monotremes (woodcut, fig. 15, *Echidna*) the ilium (*g*) extends far in front of the acetabulum (*h*), and furnishes only an arched roof of that cavity, the inner wall of which (*i*) remains membranous, as in the Bird. The pubis (*a*), after extending hæmad (forward or downward) to the pectineal process (*c*), bends there to be continued backward, as in *Ornithorhynchus*. As a rule all Mammals resemble Birds in a backward extension of more or less of both pubis and ischium, from their iliac articulations.

Thus the character asserted to be peculiar to *Dinosauria* among Reptiles exists in both the Pterosaurian and Crocodilian orders of that cold-blooded class; and, amongst warm-blooded Vertebrates, it is common to Mammals with Birds.

In my 'Anatomy of Vertebrates' I remarked, "the transference of the weight of a horizontal trunk upon a single pair of legs necessitates an extensive grasp of the trunk-segments. When the legs require to be pulled far and strongly back, as in diving and cursorial motions, the origins of the requisite muscles are extended far behind the limb's centre of motion, as in the pelvis of Grebes, Loons, Ostriches, and Emus. When the bird slowly stalks, or hops, or climbs, or uses its legs chiefly in grasping and perching, the pelvis is short and broad, especially behind; its breadth may even exceed its length, as in *Cyclarius guanensis*."*

The antacetabular part of the ilium in Birds is usually the longest, but its outer surface is not divided or interrupted by the super-acetabular plate and ridge peculiar to Dinosaurs. To the degree in which the pelvis is produced behind the acetabulum (as in woodcut, Fig. 14, *b*), such production helps to transmit the weight of the body upon the legs in a relative position thereto more favorable to the support of such weight; if the pubis

* 'Anatomy of Vertebrates,' vol. ii, p. 37.

were directed forward instead of backward, it would detract from this relation of the pelvis to bipedal progression. Nevertheless, the balance of the parts so carried in the Bird preponderates forward; the weight of the body with the head and fore-limbs is greatest in advance of the acetabula.

Among the modifications which are associated with the backwardly produced ilia, ischia, and pubes, in relation to the terrestrial progression peculiar to Birds, may first be noted the great extent of the axial trunk-bones welded into one mass where they are grasped by the bones transferring such mass upon the heads of the femora.

In no Birds are the sacral vertebræ so few as in *Dinosauria;* and in those Birds which, from their size and terrestrial habits, are cited to exemplify Dinosaurian affinities, and which best lend themselves to test the question of the locomotion of the great extinct Reptiles, the number of the sacral vertebræ is from 18 to 20. The several species of *Dinornis* had from 17 to 20 sacrals; 12 is the average number in *Natatores*, 12 in *Grallæ* and *Gallinacea*, 11 in *Altrices*. The highest number of sacral vertebræ yet found in *Dinosauria* is 5:* in *Dicynodontia* it is 6. The Sloths have 6 (Ai) or 8 (Unau) sacral vertebræ. The extinct Megatherioids, from the great share taken by the massive hind limbs in supporting the body while the fore limbs were engaged in disbranching trees, have a correspondingly closer resemblance to Birds in the structure and proportions of their pelvis than any known extinct Reptiles present. The *Mylodon* had not fewer than 11 anchylosed sacral vertebræ.†

In Birds, the trunk, properly so called, as distinguished from the neck, is singularly short; its production in advance of the pelvis is reduced to the utmost, consistently with its visceral relations.

The number of vertebræ between the neck and pelvis, *i.e.* of such as bear pairs of moveable ribs, averages 8, and never exceeds 10; and of these anchylosis commonly fetters the major part.

Between such vertebræ and the skull the 'cervicals' are as exceptional in excess, numerically; and this concurs with the exceptional reduction of number in the 'dorsals;' both being in special physiological relation to bipedal support and progression.

The numerous cervicals have peculiar joints, governing the sigmoid flexure and oscillating sway of the long and slender neck; whereby, in walking, both neck and head, in Birds, may be brought more directly over the supporting columns of the hind limbs as these change their position. These limbs, moreover, have their specialties in relation to their peculiar work in the vertebrate series.

The femur (Fig. 14 (*Dinornis*), *f*) is relatively short; the tibia (*t*) relatively long; the fibula (*fb*), styliform and short, takes no share in the ankle-joint, but co-operates with the tibia in a special manner to extend and strengthen the articulation of the leg with the thigh. The femoral condyles are concomitantly modified to effect the accessory femoro-fibular

* They may in an exceptional instance extend to 6, but demonstrative evidence of this excess has not come to my knowledge.

† 'Description of the Skeleton of an Extinct Gigantic Sloth,' &c., p. 64, pls. i, x, 4to, 1842.

joint. Nothing of this exists in Dinosaurian or other Reptiles. Still more special is the modification in Birds by which the leg is united with the foot. No break in the column charged with the sustaining function peculiar thereto in the Bird is allowed beyond the absolute necessities of bending movements of such column when subserving locomotion.

The tarsal segment is suppressed; the metatarsal segment (*mt*) is aggrandised, lengthened out and confluently compacted; the metatarsals of three toes are welded into one bone.

The joint of the leg with this bone is closely and tenaciously trochlear, strictly limiting the movements of the foot to one plane. The long and slender phalanges stretch forward at right angles to the metatarsus, and diverge to form a suitable base for the columns to which has been assigned such an unique task—so peculiar a work—as is performed by the hind limbs on the feathered class.

Certain Dinosaurs wielded carpal spines and some Mammals bore tarsal ones. It would be as germain on that ground to derive *Chauna* or *Palamedea* from *Iguanodon* or *Omosaurus*, as *Platypus* from *Phasianus*.

What are the known structures in *Megalosaurus*, *Iguanodon*, and other *Dinosauria*, which, corresponding with those in Birds, would justify the conclusion or suspicion that the ischium and pubis, besides being long and slender, as they are demonstrated to be in *Omosaurus*, were directed from their acetabular ends backward parallel to one another? It is certain that the ischium in *Iguanodon* had not the 'obturator' process characteristic of the same bone in Birds, and as certain that there must be a mistake about the matter when the same is predicated of the pelvic bone, erroneously called ischium, in the immature or small kind of Iguanodon which has been termed '*Hypsilophodon*' in ignorance of the true structure of the mandibular teeth.

That the pelvic bones, truly homologous with ischia, were "united in a median ventral symphysis,"* is most probable from the shape and surface of the somewhat expanded distal extremities of the unquestionable ischia in *Omosaurus*. But such union does not exist in Birds. If it should be found in all *Dinosauria*, it is one of the majority of characters in which that order differs from the class of Birds and agrees with its own class, viz. the Reptiles.

Of the comparatively few sacral vertebræ in *Dinosauria* the 'costal portions of the transverse processes' (pleurapophyses) abut chiefly against the part of the ilium contributing to the cup to be upborne by the thigh-bone; there are no postacetabular abutments against other parts of the ilia, or against the comparatively broad ischia, as in Birds. In the latter pelvic character we have again to quit the Reptilian class and to indicate the repetition of it in certain bird-like Lissencephalous Mammals.†

The augmentation of number of sacral vertebræ beyond that—two—in Crocodiles and Lizards, whose bellies trail upon the ground or are but little raised therefrom by the out-

* Huxley, 'Quarterly Journal Geol. Soc.,' vol. xxvi.

† 'Anat. of Vertebrates,' ii, pp. 397—402, figs. 263, 264, 266—268.

sprawling fore and hind limbs in running along, relates in Land-tortoises to a more vertical position of the leg, and to the greater weight which the entire hind limb has to sustain in the progression of those Reptiles.

In Dinosaurs (woodcut, Fig. 12) the thigh (*f*), as well as the leg (*tb*), were probably less obliquely disposed, in quadrupedal locomotion, than in any existing Reptiles, save, perhaps, the Chameleons. The four or five sacrals, interlocked, as in Birds and Tortoises, by alternating centrums and neural arches, have been recognised as physiologically related to correspondingly developed hind-limbs and a concomitant carriage of their huge elongate trunk, in a way approaching to that in the large gravigrade Mammals.*

It is requisite, in the present test, to determine as nearly as may be the relative length of the pre-pelvic part of the trunk to the pelvis in Dinosaurs.

It may be presumed that those who represent the pubic-ischial elements of such pelvis, as being disposed in the avian fashion, intend the inference that, so far, the pelvis of the Dinosaurs related to the same bipedal mode of progression as in Birds, and that the trunk was similarly borne along, prone, upon the single pair of hind-legs.†

If, however, our knowledge of the dinosaurian pelvis being rectified, it should be averred that the trunk of the Iguanodon or Megalosaur might be otherwise carried than in Birds, that it was reared upright and so balanced, as in Man, upon a pair of hind, or in that case lower limbs, it may then be necessary to enter upon a series of comparisons between the dinosaurian and human skeletons in connection with such upright mode of progression.

At present I shall not spend time in analysing the grounds of such view ; but, returning to the avian comparison, I may remark that the number of free vertebræ between the sacrum and skull, in *Iguanodon*, is 24, of which 7 are cervical, 17 dorso-lumbar; in *Megalosaurus* present evidence supports an estimate of 23 such free vertebræ allowing 7 to the neck ; in the parts of the skeleton of the same individual *Hylæosaurus*, in the British Museum, 10 vertebræ in natural succession include the hinder cervicals and succeeding dorsals, but the more or less complete vertebræ scattered in the same mass of matrix support an estimate of the vertebral formula not less in number than in *Iguanodon ;* whilst, as such vertebræ are shorter in proportion to their breadth than in either *Iguanodon* or *Megalosaurus*, there may have been more than 24 between the skull and sacrum. In *Scelidosaurus* 16 dorso-lumbar vertebræ are shown in succession in the blocks of lias in which they have been exposed, and 6 at least, if not 7 cervicals, are also evidenced in the same instructive skeleton of one individual Dinosaur.

* 'Report on Brit. Foss. Reptiles,' 1841.

† "Not a ground-crawler, like the alligator, but moving with free steps chiefly, if not solely, on the hind limbs, and claiming a curious analogy, if not some degree of affinity, with the ostrich." Phillips, 'Geology of Oxford,' p. 196. Such an idea, if it ever 'suggested itself' to my mind, was never expressed, and must have been instantly dismissed through considerations akin to those detailed in the text.

The proportion of the skeleton of *Cetiosaurus longus* in the Oxford Museum and that of the allied Dinosaur (*Omosaurus armatus*) in the British Museum demonstrate the absence of anchylosis in the dorso-lumbar region of the spine, and of any of the modifications of the hindmost vertebræ which, in Birds, add to the mechanical bracing of the trunk upon the pelvis: they show no lengthened pleurapophyses, having free proximal articulations to anterior sacral vertebræ; but, on the contrary, as in Mammalian quadrupeds, the lumbar ribs are short, coalesced with their vertebra, and project as straight outstanding transverse processes, not opposing the lateral movements of the trunk upon the pelvis, but, with the antecedent vertebræ, negativing the notion of any action of muscles, proceeding from the pelvis and thigh-bones to grasp fast a trunk, and uplift it, together with the fore-limbs, neck, and head, clear of the ground, as during the hypothetical bipedal march and course of the huge dinosaurian Reptiles.

The ascertained conformity of organisation in known *Dinosauria* supports the conclusion that a long, bulky, bendible body stretched forward from the pelvis and hind limbs throughout the order.

In Birds the bony 'vertebral' and 'sternal' ribs of the few vertebræ of their short dorsal region are spliced together by a mechanism of which no trace has hitherto been discovered in the corresponding more lengthened region of the spine of *Dinosauria;* there is a like absence, in these cold-blooded vertebrates, of the anchylosis of centrums, and of ossified tendons or neurapophysial splints—avian structures—which limit, to the essential minimum, any movement between one prepelvic vertebra and another. Every modification of the Bird's skeleton concurs to facilitate the carriage of the prone trunk, as one compacted mass, upon the vertical pair of limbs, and not one of these modifications exists in Reptiles recent or extinct.

What, then, we next ask, were the arrangements in the neck to diminish the difficulty which the known structure and proportions of the trunk oppose to the bipedal progression of *Dinosauria?*

Nothing of such exists in the length of the neck, nothing in the number or in the freedom of flexibility in opposite directions of the cervical vertebræ; on the contrary, those vertebræ in *Dinosauria* which are anterior to the bearers of the long and free ribs are few in number, with the little flexibility allowed by their reciprocal joints checked by the disposition of their short and mostly imbricate ribs. The neck of the Dinosaur was short, straight or nearly so, and strengthened by the overlapping pleurapophyses for the carriage of a massive head projecting forward almost in a line with the body: never could such head be carried back, by a graceful sigmoid bend of a long neck, so as to be poised above the centre of support afforded exclusively by a hind pair of limbs.

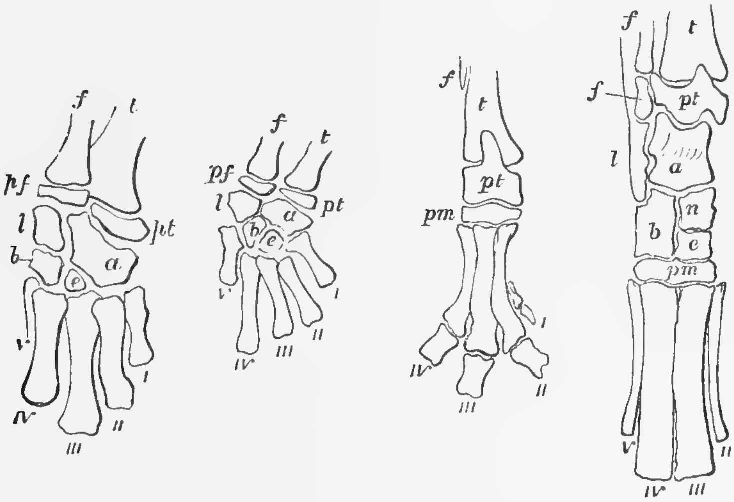
Such head, with its powerful jaws and their dense and weighty dental armature, needed the development and structure of a pair of fore-limbs, to sustain it with the fore part of the trunk, and take the required share in bearing along the bulky dinosaurian quadruped. *Omosaurus* adds a pregnant instance of the requisite anterior pair of supports.

What the Dinosaur needed for its mode of terrestrial locomotion the Bird has not; and what the Bird possesses for its mode of terrestrial locomotion the land Reptile is devoid of.

I have alluded to the modifications, extreme and beautiful they are, of the hind limb-bones of the Bird for the functions concentrated therein; the suppression, viz., of the tarsal segment; the simplification, unification, consolidation of the segments above and beneath it; the tibia alone (woodcut, Fig. 14, *t*) articulating with the metatarsus, ib., *mt*, by a finely fashioned, close-fitting, interlocking joint.

As in all warm-blooded quadrupeds and the majority of cold-blooded ones, recent and

Fig. 16.



Scelidosaurus. Varanus. Young Dinornis. Ruminant.

extinct, the articular ends of the tibia are ossified independently of the shaft, are in the condition of epiphyses in the young Bird (Fig. 16, *Dinornis*, *p t*), and retain longer that condition in the Reptile (Fig. 16, *Varanus*, *p t*, and *Scelidosaurus*, *p t*). The attachment of the distal epiphysis with the shaft of the tibia (*t*) is made firmer in the biped (*Dinornis*, *p t*) than in the quadruped (Fig. 16, Ruminant, *p t*); and the extent of the attachment is greater, is more irregular or interlocking in the warm-blooded quadruped than in the cold-blooded one; it is still greater in the Bird, in which a process, longer than that in the Ruminant, ascends upon the front of the diaphysis, closely fitting to a groove there, and clamping, as it were, the articular epiphysis to the main shaft of the leg bone. The bigger the Bird the greater the share of locomotion allotted to the hind pair of limbs in standing, walking, or running, the longer is the clamping process and the later is the period of the coalescence of the epiphysis with the shaft. The Ostrich among existing *Cursores*, and the Dinornis amongst

extinct ones exemplify this relation. In the metatarsus of the Bird the shafts of the ento-, meso-, and ecto-metatarsi are severally ossified from separate centres, but the proximal epiphyses of the three bones are ossified from one centre, and form a single cap of bone where the shafts are still distinct.* Such cap (Fig. 16, *Dinornis*, *p m*) may be arbitrarily homologised with one or more bones of the distal tarsal series in Reptiles (Fig. 16, *Scelidosaurus*, *b*, *e*; in *Varanus*, *b*, *e*) and in Mammals (Fig. 16, *Ruminant*, *b*, *n*, *e*). It seems more natural to regard it as answering to the epiphysial cap, covering the ends of the two chief metatarsals, of the Ruminant (ib. ib., *pm*, *iii*, *iv*), and I associate such instances of complex osteogeny of the metatarsus with the high conditions of organisation differentiating the warm-blooded classes, *Aves* and *Mammalia*, from the cold-blooded *Reptilia*.

In the Ruminant, as in the Bird, the single epiphysis and multiple diaphyses coalesce into one so-called 'cannon bone.'

In the Dinosauria the hind limbs are not adapted, as in the Birds, for transference of the entire weight of trunk, neck, head, and fore limbs, from the leg upon the foot by due development and modifications of the main leg-bone, the tibia; but the fibula is continued to the ankle-joint, and takes a larger share in its formation than is usual in Mammals. Both leg-bones have their distal epiphyses (Fig. 16, *p f*, *p t*. *Scelidosaurus*, *Varanus*). The tarsal segment is represented, usually by four ossicles: one, *a*, answers, by its connections, to the astragalus, naviculare, and entocuneiform bones of the Mammal; a second, *l*, represents the calcaneum with the lever process slightly if at all developed; there are, also, a cuboid, *b*, and an ectocuneiform, *e*. The metatarsals, whether they be three or four in number, never coalesce, but retain their primitive distinctness throughout life. The sole ground taken to bridge over this significant difference in the structure of leg and foot in the Bird and Dinosaur is to affirm that the distal epiphysis, *pt*, of the tibia in the Bird is the homologue of the astragalus in the Mammal and Reptile (Fig. 16, *a*).†

"If the whole hind-quarters, from the ilium to the toes, of a half-hatched Chicken could be suddenly enlarged, ossified, and fossilised as they are,"‡ the ilium would be distinguished from that of a Dinosaur by the major number of its sacrovertebral attachments and by their greater extent, by the absence of the ridge continued from the superacetabular plate upon the antacetabular one; the pelvis would be distinguished by the presence in the ischium of an obturator process wanting in the Dinosaur (Fig. 12, *is*), and by the absence of a pectineal process of the pubis present in the Dinosaur (ib., *pb*), by the parallelism of the ischium and pubis, and by the backward extension of both bones (compare Figs. 12 and 14). The differences grow and multiply as the comparison proceeds; as, *e.g.*, by the non-extension, in the Chick, of the fibula (Fig. 14, *fb*) to the ankle-joint and by the larger and more complex distal epiphysis of its tibia (Fig. 16, *Dinornis*), by the

* 'Transactions of the Zoological Society of London,' 4to, vol. iv (1856), p. 149, pl. xlv (*Dinornis elephantopus*, pullus; *Dinornis crassus*, pullus).

† Prof. Huxley, 'Quarterly Journal Geol. Soc.,' vol. xxvi, p. 29.

‡ Ib., loc. cit., p. 30.

absence of a tarsus, by the backward direction of the innermost or first toe (Fig. 16, *i*), as contrasted with the parallel position of that toe with the second toe in the reptilian foot (Fig. 16, *Scelidosaurus, Varanus*). If the entire skeleton of an immature Chick, Ostrich, or Moa were enlarged, whether suddenly or gradually, to the dimensions of that of a Cetiosaur, and were so ossified and fossilised, the characters of the dorsal vertebræ, of the cervical vertebræ, of the skull, and the absence of an anterior pair of limbs with fore-paws organized to be applied to the soil and take their share in the support and progression of a long and bulky trunk and massive head as in the Dinosauria, would be decisive against the reference of such imaginary gigantic Chick to any known representative of the Dinosaurian order of Reptiles. But, to the Biologist who rejects the principle of adaptation of structure to function, the foregoing facts and conclusions will have no significance.

By a modification of the hind-limbs the Bear, and by addition of a longer sacrum to plantigrade feet the Ground-sloth, may assume a crouching bent-kneed attitude and hold the fore-limbs free to grapple with a foe or a tree.

Such is the plasticity of some mammalian structures that, by due training, a Bear, a Dog, or a Monkey may be taught to dance and walk erect for a brief space. It may be doubted whether a cold-blooded, small-brained Reptile could by any training be brought to exemplify the mode of motion conceived in the quotation at p. 609, note †. But that, like the Chlamydosaur with its long-toed, wide-spread, hind feet, the huge Dinosaurs might assume the fighting posture of the Bear, when occasion called them to wield their carpal weapons, is conceivable without commission of physiological or anatomical solecism.

The woodcuts, p. 603, Figs. 12, 13, 14,* give the pelvis and hind limb of a Moa (*Dinornis*) and of a Crocodile (*Crocodilus*) for comparison with the corresponding parts of a Dinosaur (*Omosaurus*): the position, proportions, and structure of the foot of which are guaranteed by those of *Iguanodon* and *Scelidosaurus*.

In the Crocodile the foot may be applied flat to the ground and the thigh turned out nearly at right angles to the body; but, in some phases of progressive motion, the limb can assume the position delineated: the same may be predicated of the Dinosaurian Reptile. The Bird occasionally rests on the foot, with the metatarsus flat to the ground: but the thigh cannot be turned outward at the angle, which is possible in the Dinosaur and Crocodile. When an accessory trochanter is present in the femur of a Dinosaur (*Iguanodon, Scelidosaurus*), it projects from the inner border of the shaft, not from the outer one, as in the restoration given in Fig. 3, p. 27, 'Quart. Journal Geol. Soc.,' vol. xxvi, 1870.

* The letters have the same signification throughout; *il*, ilium; *a*, antacetabular plate; *b*, postacetabular plate; *ib* (in the Dinosaur) marks the superacetabular plate; *is*, ischium; *pb*, pubis; *f*, femur (of this only the lower part of the bone is given, so as not to conceal parts of the pelvis important in the comparison); *t*, tibia; *b* or *fb*, fibula; *as*, astragalus; *ca*, calcaneum; *cb*, cuboides; *i*, inner or first toe; *ii*, second toe; *iii*, third toe; *iv*, fourth toe; *v*, rudiment of fifth toe.

When the question as to the power of predicating homologies both special and general, as in the case of the bones of the vertebrate skeleton,* became finally accepted, the hypothesis of the successive incoming of specific forms or modifications of the vertebrate archetype through the operation of secondary causes was the only one which could adapt itself intelligibly to the facts. In enunciating my conviction that 'nomogeny,' *i. e.* natural laws, or secondary causes, had so operated "in the orderly succession and progression of such organic phenomena," I laid myself open to comments from opposite quarters. On the one hand, the admitted ignorance of the nature and mode of operation of such secondary cause or causes led to the rebuke by a Successor in the chair of the Hunterian Professorship, to wit, that, as to the secondary origin of species, my 'trumpet gave an uncertain sound.' On the other hand, an able, theological critic blew the following note of alarm:—"It is not German naturalists alone who are contributing to diffuse scientific Pantheism. We have in England an anatomist, Richard Owen. To call him an atheist because of his scientific conclusions would be an impertinence; nevertheless, in a lecture on 'The Nature of Limbs' which was delivered at the Royal Institution of Great Britain in February last, and has since been published, he brings all his scientific knowledge and demonstrative skill in support of what is called the THEORY OF DEVELOPMENT, and which has become popularly known by its introduction into the book called the '*Vestiges of Creation.*' This theory of development, as our readers may know, assumes that GOD did not interpose to create one class of creatures after another as the consequence of each geological revolution; but that, through the long course of ages, one class of creatures was *developed* from another. Now, Richard Owen undertakes to demonstrate *scientifically* (and his demonstration is very rigorous) that the arms and legs of the human race are the later and higher developments of the ruder wings and fins of the vertebrated animals—that is, those which have a true backbone; and he shows in the splint bones of the foot of a horse, bones analogous to those of the fingers of the human hand. Therefore he concludes that GOD has not peopled the globe by successive creations, but by the operation of general laws."†

The sole ground for Professor Flower's depreciatory remark is my acknowledgment of being "as yet ignorant"‡ of the nature or way of operation of such general or secondary laws; and I regret to say that after all that has been advanced since 1849 in the endeavour to elucidate the way in which one species may be transmuted into another, I am still in need of light.

Assuming that the ornithic modification of the vertebrate archetype was one of those under which the 'vertebrate idea' became embodied in the course of progression from

* 'Hunterian Lectures,' Royal College of Surgeons, 1844; 'Reports of the British Association for the Advancement of Science,' "On the Archetype and Homologies of the Vertebrate Skeleton," 8vo, 1846; and 'Discourse on the Nature of Limbs,' 8vo, 1849.

† 'Little Lectures on Great Topics,' 12mo, 1849.

‡ 'On the Nature of Limbs,' p. 86.

"its old Ichthyic vestment,"* two questions present themselves:—Out of what antecedent vertebrate modification was the avian one evolved? How, or under what conditions or secondary influences, was such evolution effected?

The hypothesis of the bipedal locomotion of the *Dinosauria*, the advocated homology of their os pubis with the ischium of the bird, and the alleged restriction of the avian antacetabular production of the iliac bone to the *Dinosauria* among Reptiles, have been superadded to the proved fact of a correspondence of structure between the shorter sacrum of the Dinosaurs and the longer sacrum of Birds as grounds for the conclusion that Birds are transmuted Dinosaurs, and that the feathered class made their first step in advance under the low form of *Struthiones* or *Cursores*, incapable, as yet, of flight. The kind and amount of modification required to evolve an Ostrich out of an Iguanodon may be appreciated by the osteological comparisons already submitted in the present section of this work. To revert only to the structure of the fore-limb. In losing its power of aiding in the quadrupedal progression, and of grasping or otherwise applying the hand, it has as yet, in the hypothetical first form of Birds, gained no other faculty. At best it may help in the swift course of the ostrich by flapping motions similar to those of better birds during their flight; or the more minute monodactyle hand may just serve to scratch the back of the head, as in the New Zealand Kivi. In their larger extinct relatives, the Moas, it is still doubtful whether more of the framework of a fore-limb existed than the supporting scapular arch, and that of the simplest character.

In all these gradations of structure of a limb unavailable for flight or any other mode of locomotion we see no approach in the scapula to the Dinosaurian types of that bone; it retains in all Cursorials the strictly avian sabre-like shape and pointed free extremity, without expansion and truncation there such as obtains in the alleged ancestral *Reptilia*.† The coracoid still further departs from any well-determined Dinosaurian type of the bone, and as closely adheres to that of the Birds of flight, save such decrease of breadth and of relative size as accords with its necessity to bear upon the sternum in the mechanical mode of inspiration peculiar to Birds with Pterodactyles.

What could be the conceivable conditions of the life of an Iguanodon or Megalosaur which rendered a fore-limb useless or cumbersome, and concomitantly called for lengthened and strengthened hind-limbs and a more vigorous and exclusive exercise of these in the acts of locomotion? The abettors and acceptors of the exposition of the operation of the secondary mode of origin of species by way of 'natural selection' are amenable to the call for an explanation of such conditions, especially if such mode of origin be hypothetically applied to the kinds of Birds deprived of the power of flight. But such explanation would have to square with the fact that a loss of one pair of limbs had been associated, on the assumption of the Dinosaurian ancestry, with an advance of the mechanical structure

* 'On the Nature of Limbs,' p. 86.

† Compare, for example, the scapula of the Apteryx, 'Transactions of the Zoological Society,' vol. ii, pl. xxx, fig. 2, *g*, and figs. 3 and 4, with Cut, fig. 3, p. 586.

of the organs of circulation, and a progress in the extent and perfection of the lungs, together resulting in the higher temperature, with more numerous and minute coloured discs, of the blood. For these conditions of the vital organs characterise alike both winged and wingless Birds, and the resultant unvarying warmth of the body is accompanied by a clothing of down and feathers, the most exquisite and complex of all tegumentary coverings, common to the Kivi and Ostrich with the Eagle and Swift.

But there are other hypotheses of the way of operation of secondary genesis of species anterior in date to that of Darwin. The influence, viz., of exercise and of disuse in altering the proportions of parts mooted by Lamarck;* the hypothesis of 'degeneration' propounded by Buffon; † and the effects of congenital changes in parts of the body, mainly depended upon by the author of 'Vestiges,' in his endeavour to explain the way of operation of the secondary law of the origin of species.

The comparative ease is so refreshing, after the labours of induction and dry description, in supposing a case, that I may be forgiven for indulging in a suggestion of a possibility of the few still extant wingless or flightless birds having originated, not from any lower cold-blooded vertebrate form, but from higher active volant members of their own warm-blooded feathered class. Consideration of extinct kinds, in the restoration of which I have been occupied, has strengthened the supposition.

Here, in yielding to this indulgence, I own to finding more help from the Lamarckian hypothesis than the Darwinian one, and I am ultimately led to propound the *Struthionidæ* as exemplifications of Buffon's belief in the origin of species by way of degeneration; on other grounds than those on which my anonymous Critic, above cited (p. 614, †), views the Papuan and Boschisman in relation to an antecedent higher, indeed perfect, form of man.

Let us suppose, for example, an island affording abundant subsistence to vegetarian birds, and, happily for them, to be destitute of creatures able or desirous to destroy such birds. If the food was wholly, or chiefly, on the surface the power of traversing such surface would be of as much advantage to the bird as to the herbivorous quadruped. As flight calls for more effort than course; so cursorial progression would be more commonly practised in such a happy island for obtaining the daily food. The advent or proximity of a known element of danger might excite the quicker mode of motion; the bird would then betake itself by a hurried flight to a safer locality. If, however, certain insular birds had never known a foe, the stimulus to the use of the wings would be wanting in species needing only to traverse the ground in quest of food. In the case of New Zealand, for example, the roots of wide-spread ferns, being rich in farinaceous and amylaceous principles, the habit of scratching them out of the ground would lead to full development of the muscles of the leg and foot. So, such daily habitual exercise of legs and feet by unscared Rasorials would lead in successive generations to strange developments of hind-limbs;

* 'Philosophie Zoologique,' 2 vols., tom. i, chaps. iii, vi, vii, 8vo, 1803.

† 'Histoire Naturelle,' tom. xiv, p. 311, 4to, 1766.

whilst the disuse of the wings during the pre-Maori æons would lead to their atrophy. The Lamarckian hypothesis has, in fact, this advantage over others of like kidney, that physiology testifies to the relation of growth to exercise, and of waste to disuse, and so far votes in favour of the conditions evoked by Lamarck as *veræ causæ* in transmutation. We recognise in the stunted wings of the Dodo evidences of its affinity; as, for example, by their close conformity, save in size, and in the prominence of their processes for muscular attachments, to the scapula, coracoid, brachial and antibrachial bones, carpus, metacarpus, &c., of the perfect instrument of flight in truly winged birds, and such conformity of structure is agreeable with the hypothesis of the origin of the Mauritian species of ground-pigeon through descent or degeneration. The differences which the wing-bones of the Dodo present when compared with their homologues in the *Iguanodon* is in the same degree adverse to the hypothesis of its evolution from any such reptile, in the direction of ascent and improvement. The same course of argument applies to the impennate Awk, the Cassowary, Rhea, Ostrich, &c., as to the wingless birds of the Mascarene, Polynesian, or Melanesian Islands.

Confidence in the impartial exercise by Biologists of the logical faculty leads to the conclusion that their science will accept the view of the Dodo as a degenerate Dove rather than as an advanced Dinothere. But whence the dove? Are we then, I will not say driven, but rather guided, to the old belief that the winged bird was "created" in the sense of being miraculously made, at once, out of dust, agreeably with the alternative hypothesis conceived by my critic? Or, is a belief in a Dove's coming to be through the operation of a secondary law still legitimate and germain to our truth-seeking faculties? Not necessarily relegating an honest inquirer to the bottomless pit of Atheism, if he should happen to ask:—Were there no volant vertebrates of earlier date and lower grade than the "Fowls of the Air"?

Without knowing or pretending to know the way of operation of the secondary cause, the vast increase of knowledge-stores of biological phenomena makes it as impossible to comprehend them intelligibly in any degree, on the assumption of primary or direct creation of species, as it was impossible for Copernicus to understand and explain the vast accession of astronomical facts in his day, on the belief of the subservient relation of sun to earth, of the posteriority of the creation of the luminary to that of the light-receiver, and of their respective relations of motion, as received in his day. To the objection, how, on his assumption of the diurnal rotation of the earth, loose things remained on its surface, Copernicus could offer no explanation. Neither has the Biologist been able, as yet, to explain how the Ramphorhynchus became transmuted into the Archeopteryx. It is open, of course, for any one to deny such change. What seems to me to be legitimate, in giving an account of the labours that have resulted in a certain accession to the knowledge of extinct forms of cold-blooded, oviparous, air-breathing Vertebrates, is the indication of the respective vicinity of certain groups of such now much reduced class to the warm-blooded oviparous Vertebrate air-breathers which in our times so greatly prevail in life's theatre.

Every bone in the Bird was antecedently present in the framework of the Pterodactyle; the resemblance of that portion directly subservient to flight is closer in the naked flyer to that in the feathered flyer than it is to the fore-limb of the terrestrial or aquatic Reptile. No Dinosaur has the caudal vertebræ reduced as in Birds; many Pterodactyles manifest that significant resemblance. But some Pterodactyles had long tails and all had toothed jaws. A bird of the oolitic period * combined a long tail of many vertebræ with true avian wings, and it may have had teeth in its mandibles. It is certain that a later extinct bird,† though of an early tertiary period, far back in time beyond the present reign of birds, had tooth-like processes of the alveolar borders of both upper and lower jaws.

Fact by fact, as they slowly and successively drop in, testify in favour of the coming in of species by 'nomogeny,' and speak as strongly against 'thaumatogeny' ‡ or the multiplication of miracle on the alternative hypothesis of the writer of 'Little Lectures on Great Things.' He and his school invoke a cataclysm to extinguish the Palæothere, and an inconceivable operation to convert dust into the Hippothere; yet a slight disproportion of the outer and inner of the three hoofed toes of each foot of these quadrupeds is their main difference. My critic again invokes a cataclysm to extinguish the race of Hippotherian species and again requires the miracle to create the Horse. Yet the loss of the small side-hoofs that dangled behind the main mid-hoof in the Hippothere is the chief organic distinction between *Hippotherium* and *Hippos*. Every bone, every tooth, present in the eocene and miocene predecessors of modern Horses is retained in them, with slight changes of shape and proportion. The second and fourth metacarpals which bore hoofed digits of moderate size in eocene days, bore them of diminutive size in miocene days; and now, when such dangling spurious hoofs are gone, their metacarpal and metatarsal suspensories still remain, hidden beneath the skin, and ending in a point where, of old, was a well-turned joint.

It has become as impossible to square the hypothesis of "the peopling of the globe during the long reign of life thereon, by successive and special creations" with the known vital phenomena, as it was impossible to explain the sum of astronomical facts, accumulated in the fourteenth century, by the cumbrous machinery of cycles and epicycles, necessitated under the assumption of the globe as the fixed, central, and largest body of the Universe. Biology seems now to be at the Copernican stage; and if the rejection of the incoming of species by primary creative acts should exercise an influence on the progress of that science akin to that of astronomy after the abandonment of the faith in the earth's fixity, Biologists may confidently look for as rapid a progress through acceptance of Nomogeny.

What, then, may be the meaning of the reduction of bulk in the fore-limbs of certain Dinosaurs? Does that reduction indicate a step in the conversion of such Reptiles into

* *Archeopteryx*, 'Philosophical Transactions,' 1863.

† *Odontopteryx*, 'Quarterly Journal of the Geological Society,' 1873.

‡ 'Anatomy of Vertebrates,' 8vo, vol. iii, p. 814.

Birds? Do we get an explanation of the small fore-limbs by the picture which Professor Phillips, under Huxleyan guidance, vividly presents to us "of the grand and free march on land chiefly, if not solely, on the hind-limbs?" Or, is the fact of the disproportion of size between the arms and legs in the Megalosaur and Iguanodon susceptible of other than the Oxfordian hypothesis?

As a matter of fact, such disproportion is shown by Crocodilian Reptiles still in existence; whilst extinct Crocodiles of more aquatic habits and marine sphere of life had the fore-limbs as much reduced in size as in any known Dinosaur.* Of this *Teleosaurian* character the physiological explanation which has been advanced is, that the course of such Crocodile through water, due to the action of the long, laterally flattened tail, would be facilitated, or less impeded, by such reduction of size of the fore-limbs; those limbs taking no share in the forward dash of the piscivorous reptile in pursuit of its prey, and, if of any use in the water, being limited in natatory evolutions to assist in a change of direction; the fore-limbs, in fact, being mainly if not wholly required to help in the progress of the amphibious beast upon dry land, or to scratch out the nest in the sand. Actual observation of a swimming Crocodile or Lizard testifies to the fore-limbs being then laid flat and motionless upon the sides of the chest. All known Dinosaurs have the Crocodilian swimming organ; the Iguanodon exemplifies the compressed vertically broadened tail in an eminent degree. And just as such appendage was essential to the proportion of the active life of these huge cold-blooded amphibians which was spent in the watery element, so such far-produced caudal fin must have been a cumbrous impediment to the way of walking upon dry land pictured in the Work and Paper above cited.†

In the ratio in which the fore-limbs approach the hind ones in size may be inferred the proportion of time spent by the huge reptile on land, and the importance of the share taken by these limbs in such quadrupedal mode of progression: when the Dinosaur betook itself to water its fore-limbs would be, most probably, disposed as in the Crocodiles.

If, then, the hypothesis that the reduced fore-limbs of *Dinosauria* receive the most intelligible, and therefore acceptable, explanation, admitting the principle of adaptation of structures to functions and reciprocally, agreeably with the analogy of such living animals as are most nearly allied to them in organization; the notion that Birds, under their wingless conditions, were derived from Dinosaurs may be safely left to the judgment of whomsoever may be disposed to bring unprepossessed and impartial judgment to the consideration of the hypothesis.

* 'Crocodilia,' Plate 1, of the present Work, and "Monograph on the Fossil Reptilia of the London Clay," part ii, in the Volume of the Palæontographical Society for 1849, p. 24, t. xi.

† Phillips, 'Geol. of Oxford,' p. 196; and Huxley, 'Quarterly Journal of the Geological Society,' vol. xxvi.

Genus—Omosaurus.

(*Continued.*)

Species—*Omosaurus hastiger*, Owen. ('Dinosauria,' Plates 77 and 78.)

If the grounds assigned in a former part of this work (p. 577) for the probable homology of the unsymmetrical spine figured in Plates 74 and 75, which spine was found with the bones of the fore-limb of *Omosaurus armatus*, should be deemed to warrant such conclusion, a similar one may be provisionally accepted as applicable to the pair of spines of similar size and character discovered in the same division of the Kimmeridge Clay, in the Great Western Railway Cutting at Wootton Bassett, Wiltshire, briefly referred to at p. 577.

Many large Saurian fossils were collected from the sections of Kimmeridge Clay at that time exposed; but none have reached me save the subjects of the present Monograph, which were there obtained by William Cunnington, Esq., F.G.S., and have passed with the rest of his collection into the possession of the British Museum. The apical portion of each spine has been broken away, but the degree of decrease from the base affords satisfactory grounds for the restoration given in Plate 78, the ratio of decrease being less in the present species than in the almost perfect spine of *Omosaurus armatus* (Plate 74).

The base of the spine (Plate 78, *b*) expands from the body, *a*, more suddenly and in a greater degree in *Omosaurus hastiger*. It is suboval in form and, as in *Omos. armatus*, its plane is oblique to the axis of the spine. The long diameter of the base is 9 inches, the short diameter is 7 inches.

The articular surface is divided into two unequal facets by a low ridge of the base (Plate 77, fig. 1, *r*, *r*) parallel with the long diameter of the base; each facet is feebly convex lengthwise, less feebly concave transversely. The surface for attachment is roughened by low short ridges diverging from the long ridge, *r*, and is irregularly pierced by vascular canals; the borders are thick and irregularly notched.

The body of the spine is continued more directly from one end (Plate 78, figs. 1, 2, 3) of the oval base, *a*, fig. 2, sloping and expanding more gradually to the opposite end of the base, *b*, fig. 2.

The body of the spine is a full oval in transverse section (ib., fig. 4), pointed at each end, where the two opposite edges, *d*, *e*, are cut. The anterior edge (fig. 1, *d*), begins about 6 inches beyond the anterior produced part of the base; the posterior edge (fig. 3, *e*) begins about 2 inches from that end of the base. Both edges extend along the preserved portions of each spine, and were probably continued to, or near to, the pointed

end. An additional advantage as a lethal or piercing weapon must have been derived from this two-edged structure.

In the right spine (fig. 1) the length preserved is 14 inches; in the left spine (fig. 3) the length preserved is 10 inches. Each spine may be estimated to have been upwards of 20 inches in length when entire.

The transverse section taken from the broken end of the left spine (fig. 4) gives 4 inches and $3\frac{1}{4}$ inches in the two diameters: the broken end of the better preserved spine gives 3 inches and $2\frac{2}{3}$ inches in the two diameters; the spine approaches to a circular section as it nears the pointed end. The texture of the outer inch is a compact bone susceptible of a high polish; it becomes finely cancellous within a few lines of the central cavity, the section of which at the part cut, viz. $8\frac{1}{2}$ inches from the base of the spine, gives 1 inch 6 lines, and 1 inch 3 lines, in the long and short diameters.

The close correspondence of the present fossil in general form, in basal modifications for attachment, and in texture, with the spine, probably left carpal, of *Omosaurus armatus*, will be obvious on comparison of Plates 77 and 78 with Plates 74 and 75 of a former part of this work, treating of that species; and such correspondence may be deemed to support the provisional reference of the carpal (?) spines from the Kimmeridge Clay of Wootton Bassett to the same genus as that from the Kimmeridge Clay of Swindon; they manifestly indicate a distinct species on the above hypothesis of their nature. The osseous core of the carpal spine in *Iguanodon* (p. 508, Plates 46, 47) differs chiefly in its relative shortness or speedier diminution from the base to the apex.

After a comparison of these fossils with all the examples of carpal and tarsal spines in existing vertebrates, I found the nearest resemblance to the basal expansion, by which the spine of *Omosaurus* has been attached, in the tarsal spine of the Platypus (*Ornithorhynchus paradoxus*, Plate 77, fig. 2, twice natural size). There was the same proportion of breadth to the body of the spine; the same sudden expansion to form the base; the same medial rising in the long axis of the base, and furrows extending therefrom to the margin. But these radiating furrows are more numerous, and the spine, though it is hollow as in *Omosaurus*, has that cavity converted by terminal apertures into a canal, and this canal is traversed, as in the poison-fang of certain Ophidian Reptiles, by the duct of a gland. The affinity shown by the Monotrematous Mammals to the *Reptilia* in certain parts of the skeleton is well known, and is closer in the structure of sternum, coracoids, and clavicles, than in any Bird.

ORDER. *DINOSAURIA.*

Genus—CHONDROSTEOSAURUS.

Species—*Chondrosteosaurus gigas*, Owen. ('Dinosauria,' Plates 79—82.)

The flatness of the under surface of the vertebra figured in Plates 79—82 recalled the character of that of *Bothriospondylus suffossus* (p. 551, Plate 61), and, with the predominance of the transverse over the vertical diameter, suggested that it also might have come from the sacral series.

The hemispheroid convexity, however, of the anterior end, notwithstanding abrasion of the articular surface itself, and the proof of its truly indicating such form given by the more perfect preservation of that surface in the opposite concave articular end (Plate 80), too plainly pointed to a much more forward position of this remarkable vertebra in the backbone series of the huge Reptile which it represents.

That the vertebra is from the fore part of the trunk may be inferred from the presence, on each side, of both a parapophysis (Pl. 79, *p*) and a diapophysis (ib., *d*), indicative of the bifurcation of the proximal end of the rib into a capitular and a tubercular articulating process.

The portion of neural canal preserved (Plates 80 and 81, *n*) gives the vertical diameter of the centrum. There is no indication in the concave articular surface of that diameter having been diminished by posthumous pressure. The gentle transverse concavity of so much of the broad under surface as is preserved (Plate 79) is evidently natural. The deep depression (Plate 82, fig. 1, *f*) on each side of the centrum between the par- and di-apophyses recalls a vertebral character of the genus *Bothriospondylus*.

The parapophysis (Plate 79, fig. 1, *p*) projects from the level of the under surface: it commences behind, four inches from that end of the vertebra, as an extension of the lower border of the centrum, curving outward and gaining vertical thickness as the process advances (Plate 82, fig. 1, *p*), the fore part of the base of the process occupying the lower vertical half of the centrum, and terminating very near to the beginning of the anterior articular ball.

The neurapophysis (Plates 80, 81, 82, *ns*), which has coalesced with the centrum, begins to rise about two inches in advance of the hinder cup. The part of the broken base there preserved yields a transverse thickness of $3\frac{1}{2}$ inches. Anterior to this the upper surface of the centrum has been abraded to the level of the neural canal, but sufficient is preserved to show that the neurapophysis loses thickness at the middle of the vertebra, and appears to regain it as it approaches the anterior ball (Plate 81, fig. 1).

The base of the diapophysis (Plate 81, fig. 1, *d*), at the part of the neurapophysis pre-

served, gives a fore-and-aft extent of $3\frac{1}{4}$ inches, and a vertical diameter of 2 inches, from which the size of the tubercle of the rib may be inferred.

Restoring the margin of the posterior concavity and the articular surface of the anterior convexity, the length of the centrum of this vertebra would be 1 foot 3 inches.

The whole of the side of the centrum is occupied by a deep oblong depression which, probably, lodged a corresponding saccular process of the lung. On one side this depression was partially divided by a thin oblique plate (Plate 82, fig. 1, *f, f*). I deem it much more probable that the large cancelli obvious at every fractured surface of this vertebra (ib., fig, 2) were occupied in the living reptile by unossified cartilage, or chondrine, than by air from the lungs, and consequently have no ground for inferring that the whale-like Saurian, of which the present vertebra equals in length the largest one of any Cetacean recent or fossil, had the power of flight, or belonged to either *Pterosauria* or *Aves*.

The neural canal (Plate 81, *n*) indicates a centre of origin of motory nerves subservient to less energetic, more sluggish, movements than in the volant groups; movements probably exercised more commonly in the aqueous than the gaseous atmospheres; and it leads to the inference that, when emerging, the huge frame was sustained by the solid earth on limbs of dinosaurian proportions.

The neural canal at the middle of the vertebra yields 1 inch, 3 lines in diameter, and expands to that of 2 inches at its hinder outlet; it is here, therefore, one fourth the transverse diameter of the vertebral centrum.

In a corresponding vertebra of an Eagle (Plate 81, fig. 2) the posterior outlet of the neural canal, *n*, is 4 lines in diameter, that of the end of the centrum, there, being 6 lines in diameter: the relative size of the myelon, here indicated, harmonises with the rapid and powerful exercise of muscles of flight deriving their motive energy from an adequate nervous source. The contrast in the relative size of the myelon and vertebra between the Eagle and the Chondrosteosaur is shown by figs. 1 and 3, *n*, in Plate 81.

The specimen here described and figured was obtained from the submerged Wealden deposit on the south coast of the Isle of Wight, and was purchased for the British Museum.

The extreme modification of structure in the vertebræ of *Chondrosteosaurus* contrasted with that of the subjects of Plates 61—73 leads me to refer them to a distinct genus from *Bothriospondylus;* but it is a nearly allied one.

I had a vertical longitudinal section made of a rolled and worn centrum, of smaller size than the type of *Chondrosteosaurus gigas,* but of similar proportions. It is figured three fourths of the natural size in Plate 82, fig. 2. The black tint indicates the ossified proportion of the vertebral substance; the lighter tint the chondrosal proportion, filled in the fossil by Wealden marl.

Species—*Chondrosteosaurus magnus.* ('Dinosauria,' Plates 83—85.)

In the subject of Plate 84 sufficient of the concave articular surface is preserved to show its correspondence in size with that of the subject of Plate 80, but its proportions are reversed, the vertical diameter plainly appearing to surpass the transverse one. The present vertebra, it is true, has come from a more posterior part of the column. The parapophysis has disappeared, at least from the position from which it projects in the subject of Plate 79: if such process was present its origin has risen to near the base of the neural arch. So much of the free surface of the centrum as remains is concave lengthwise; all trace of flattening of the inferior surface has disappeared. The curve of the free surface toward the fore end of the centrum indicates that vertebral element to have been shorter absolutely, and much more so relatively to the hinder cup, than in *Chondrosteosaurus gigas.* It is hard to suppose that so extreme a degree of modification of shape and proportion should be present in an anterior and a middle dorsal vertebra of the same spine or in the same species, as is exemplified by the subjects of Plates 80 and 84; I therefore refer them to distinct species. The present vertebra agrees more closely in proportions with that of which a side view is given in Plate 83.

The centrum is shorter in proportion to both breadth and height than in *Chondrosteosaurus gigas.* The rise in the position of the parapophysis shows the vertebra (Plate 83) to have come from a more posterior part of the spinal column than the subjects of Plate 79, and of fig. 1, Plate 82. The outlet of the side-pit is shorter and deeper (vertically); yet the long diameter of the aperture is about one third that of the centrum; its compact lining layer of bone is entire. The fore end of the centrum shows the convexity, the hind end the concavity, characteristic, with the chondrosal texture of the bone (Plate 85), of the present remarkable genus. The neurapophysial bases extend to within an inch and a half of the hind margin of the centrum; they rise at the beginning of the convexity of the fore end. This convexity has suffered abrasion, and the widely cancellous structure is exposed, as shown in Plate 85.

It seems not needless to remark, in reference to such fossils, that the primal basis of the vertebrate skeleton may be converted into sclerine or chondrine, and that ossification may begin in either 'membrane' or 'cartilage.' In some vertebrates, chiefly if not exclusively cold-blooded, more or less of the bone may remain unossified, retaining the antecedent stage, with some slight modification of tissue, to which, as in selachian vertebræ, the term 'chondrine' has been applied. Such partially ossified bones, when petrified, show corresponding cavities, usually filled with matrix or spar.

But this condition of fossil bones may depend on other osteogenetic changes. After substitution of bone-earth for gristle, or the conversion of the entire cartilaginous mould

into bone, the central part may be absorbed and marrow be substituted for bone. Then, in the course of fossilisation matrix or spar may be substituted for marrow. Or the absorption of previous solid bone, such as that of a chelonian humerus or femur, may go further; the marrow may also be absorbed, the wall of the bone may be perforated, or 'tapped,' and air be admitted from a contiguous portion of lung. But in the course of fossilisation the non-ossified parts of the substance of the bone become filled by the same mineral infiltration whether the cavities in the recent state contained chondrine, marrow, or air.

The inconsiderate conclusion that fossil bones with large vacuities and thin compact osseous walls and partitions must have been bones of volant vertebrates led to the supposition that certain fossil eggs belonged either to Pterodactyles or Birds, because the bones of the unexcluded embryo showed the hollow or tubular character. Such eggs in a portion of stone from a quarry in the Island of Ascension were submitted under this impression by LYELL, in 1834, to my examination. The characteristic scapula and coracoid of a chelonian embryo were detected in the petrified contents of the fossil egg. To the objection, based on the hollowness of those limb-bones, against the reference of those bones to the reptilian genus, I showed, by dissection of a newly hatched *Chelone* preserved in spirits in the Hunterian Museum, that the cavity of such bones was filled with chondrine, not with air, and I explained to my friend that the thin outer shell of bone was a transitory embryonal character, and that the femora, humeri, and other bones became massive and solid in the adult turtle.* Now, the earlier chondrosal stage in the existing genus was not overpassed but retained as the normal adult osteal character of the extinct huge and heavy reptiles of the genus *Chondrosteosaurus*.

It is a relief to banish the marvellous and awful vision of flying Dragons with vertebræ of the size of those of *Chondr. gigas* and *Chondr. magnus!*

ORDER. *DINOSAURIA* (?).

Genus—CARDIODON.

Species—*Cardiodon rugulosus*.

In the Wealden and Upper Oolitic, as in other mesozoic formations, the evidences studied in the process of restoring the Reptiles of those periods come to hand, for the most part, fragmentarily. Bones without skull, jaws, or teeth may indicate genera before unknown, such as *Omosaurus* and *Chondrosteosaurus;* or scattered teeth unassociated therewith may suggest reptiles as huge but be generically distinct from the known

* See note in Lyell's 'Principles of Geology,' vol. ii, p. 292, ed. 1835.

teeth of *Iguanodon*, *Hylæosaurus*, or *Megalosaurus*. A happy accident may one day bring to light the connection of the subjects of the present subsection with those of the foregoing of which the dental characters are unknown.

In this state of doubt it is convenient to indicate the new fossil by a distinct generic term, and such has been suggested, for the subjects of figs. 2—5 of Plate 85, by the heart-shaped form of the crown of the fossil tooth. The crown, being 1 inch in length, 8 lines in breadth, and 5 lines in thickness, might well have come, according to the proportions of the teeth of *Hylæosaurus* (Plate 39), and *Scelidosaurus* (Plate 46), from a Dinosaur with trunk-vertebræ of the size of those of species of *Chondrosteosaurus*.

In the teeth of *Cardiodon* the 'crown' suddenly expands above the 'neck,' and thins off to the fore and hind borders (Plate 85, fig. 3), and contracts to a subacute apex (ib., fig. 2). The enamel rises into wavy longitudinal ridges with widish intervals, where it is minutely rugous. The fang is cylindrical, coated with smooth cement.

The original or typical specimens of *Cardiodon rugulosus* were from the 'forest marble' of Wiltshire.*

* See my 'Odontography,' 4to, p. 291, pl. lxxv *a*.

ORDER. *CROCODILIA.*

FAMILY. CŒLOSPONDILIA.*

Genus—POIKILOPLEURON. *Eudes-Deslongchamps.*† ('Crocodilia,' Plate 39.)

THIS genus was established on fossils discovered in the Oolitic building-stone at Caen, Normandy, and the characters which have led to the recognition of evidences of the genus in our own Wealden deposits are the shape and texture of the vertebræ, and more especially the latter. By these were determined a caudal vertebra from the Wealden of Tilgate, in the Mantellian collection, now in the British Museum: which vertebra differed from the type-specimens on which the genus was founded, only by a slight inferiority of size.

M. Deslongchamps assigns the length of a 'décimètre,' or thereabouts, to his vertebræ, say 3 inches, 10 lines. The Wealden specimen, which has been fractured across the middle of the centrum, gives a length of that element of 3 inches, 8 lines; or about 9 centimeters. The vertical diameter of the articular end is 2 inches, 3 lines (58 mm.), the transverse diameter is 2 inches, 2 lines (55 mm.); the transverse diameter of the middle, contracted part of the centrum is 1 inch, 4 lines (36 mm.).

The external free surface of the vertebra is marked with faint striæ, otherwise it is almost smooth. Both terminal surfaces are of a full elliptical form, with the long diameter vertical; they deviate from flatness by a slight concavity. The centrum gradually contracts from the two extremities toward the middle: a diapophysis extends from the upper and hinder part of the side, below which there is a shallow groove, slightly bent with the convexity downward. The neural arch has coalesced with the centrum, and the base of the diapophysis extends from the hinder upper half of the centrum upon the base of the arch. A longitudinal sulcus traverses the anterior half of the under surface of the centrum. The hypapophysial surface is a single obliquely bevelled plane indicative of the confluent bases of the hæmapophyses, and this is the character of the hæmal arch preserved in the Caen specimen.

In my 'Report on British Fossil Reptiles'‡ I did not recognise grounds for specifically differentiating the Wealden *Poikilopleuron* from the *Poik. Bucklandi* of the

* This term refers to the large vacuity in the centre of each vertebral body, simulating a medullary cavity; ossification is here arrested at the middle, not, as in the *Amphicœlia*, at the two ends of the centrum.

† 'Mémoires de la Société Linnéenne de Normandie,' vol. vi, 1838, p. 37.

‡ 'Reports of the British Association,' 1841, p. 84.

Caen Oolite. Besides the Tilgate locality I was able to note, after examination of a series of fossils belonging to S. H. Christie, Esq., from the submerged Wealden Beds, Isle of Wight, the "half of a dorsal vertebra from Brook Bay, which agrees in size, in the form of the articular extremity, in the degree of median constriction, and especially in the large size of the medullary" (chondrosal) "cavity at the middle of the bone, with the vertebral characters of *Poikilopleuron*."*

Species. *Poikilopleuron pusillus*, Ow. ('Crocodilia,' Plate 39.)

This species is, to me at present, represented by eight vertebræ, an ungual phalanx of the rapacious type, and part of a medial symmetrical bone to which are articulated portions of a pair of rib-like bones, as to the nature of which the nearest guess I can make is that they represent part of the series of abdominal ribs with their sternum.

All these bones show a compact osseous texture with a smooth or polished exterior, and a section of one of the dorsal centrums exposed, what a fractured caudal one indicated, viz. a large central chondrosal vacuity, such as characterises the centrum of the Oolitic crocodilian genus *Poikilopleuron* of Eudes-Deslongchamps.

The reptile, of which the present are fossilised remains, was discovered by the Rev. W. Fox, M.A., in the south-west Wealden of the Isle of Wight; it is much smaller than the type of the genus *Poikilopleuron* from the Caen Oolite, or the Wealden vertebræ above referred to *Poik. Bucklandi*. It may be objected that the present specimens are from a young individual of the same species; but they show no signs of immaturity, and the caudal hypapophyses indicate the bases of the piers of the hæmal arch not to have been confluent as in the *Poikilopleuron Bucklandi*, and as in *Iguanodon*.

The vertebral centrums are long in proportion to their breadth and depth, and the non-articular surface is so concave lengthwise as to give the appearance of the centrum being constricted between the terminal articular surfaces. These are almost flat.

In one trunk-vertebra, the sides of the centrum converge to a carinate inferior surface. In another (Plate 39, figs. 1—3) that surface is less narrow (ib., fig. 2). In both the suture of the neural arch is traceable, but the arch has remained attached: it shows a small facet (fig. 1, *p*) for the head of the rib at the fore part of the base of the neurapophysis. A horizontal (diapophysial) ridge (ib. *d*) extends from the prezygapophysis to the upper surface of the postzygapophysis, broadening as it recedes. The neural spine is compressed, but rises from nearly the entire length of the neural arch. The outer surface of the centrum is compact, smooth, and glistening; and on making a vertical longitudinal section the more definite generic character of the large chondrosal vacuity was exposed, as in fig. 3, *ch*, 3.

* 'Reports of the British Association,' 1841, p. 84.

In the series of five vertebræ, including the three hinder lumbars and the sacrum (ib., fig. 4), the costal surface has been transferred to the diapophysial ridge, *d*, which now extends outward from a contracted base midway between the zygapophyses, the terminal articular surface being supported by a lower buttress-like ridge, *f*. The under surface of the centrum is here broader than in the preceding vertebra, and is transversely rounded: the carinate character in the dorsal vertebræ, giving space to the abdominal cavity, has here disappeared. In some of the present series the deeply concave side of the centrum has yielded to pressure, and the compact outer wall has been fractured and pressed in upon the chondrosal or *quasi* medullary cavity. In the last lumbar vertebra the diapophysis, depressed and subelongate, shows a narrow costal surface, *d'*, for a small or short 'false rib.'

The two hindmost vertebræ in this series of five are sacral (*s* 1, *s* 2). They have the crocodilian character of limited number, and the non-dinosaurian character of retaining their neural arch in normal junction with the centrum. The doubt expressed as to the ordinal affinities of *Poikilopleuron*,* in my 'Report,' is here dispelled. The diapophysis, short, but broad and deep (*s* 1, *d*), terminates in a large flattened semi-oval surface for the sacral rib. The corresponding surface upon an equally large diapophysis in the second sacral has rather less vertical extent(*s* 2, *d*). The centrums appear to have coalesced, but the primitive line of separation of the terminal expanded surfaces is traceable.

The neural spines are broken away in all this series of vertebræ, but their narrow elongate bases indicate the same character as in the detached more anterior vertebra from a smaller individual (figs. 1 and 3, *ns*).

The two caudal vertebræ (figs. 5—8) are from the terminal part of the tail where both transverse and spinous processes have disappeared. The low neural arch has coalesced with the centrum, and this, retaining its length, as in the sacral and lumbar region has diminished by loss of transverse and vertical extent. The under surface is canaliculate (fig. 7), and both the anterior and posterior expanded ends of the boundary ridges of the lower groove have articular surfaces, *h*, *h*, for a hæmal arch.

In Plate 39, fig. 9, the compressed subtriangular portion of an abdominal sternum (?) is marked *hs*; the pair of abdominal ribs which articulate by expanded thinned-off ends to the sides of *hs* are marked *h*, *h*.

The ungual phalanx (ib., figs. 12, 13) is remarkable for its degree of curvature, its strong lever-process, and the deep lateral grooves.

The value of this little specimen and fruit of Mr. Fox's persevering researches in the Wealden deposits of his vicinity is its demonstration of the limited crocodilian number of trunk-vertebræ deprived of reciprocal motion upon each other, and with transverse processes thickened and terminally expanded for junction with the pelvis.

* "Subsequent discoveries may prove it to belong, like the *Megalosaurus*, to the *Dinosaurian* order; but, as the *Poikilopleuron* is, at present, known, it seems to have most claim to be received into the cœlor spondylian family of the Crocodilian order," 'Rep. Brit. Assoc.,' 1841, p. 85.

I repeat, with some stress, this character because the experienced and accomplished palæontologist of the United States, JOSEPH LEIDY, M.D., while rightly recognising the "half of a vertebral body" from a Cretaceous formation at Middle Park, Colorado, as of a *Poikilopleuron*, remarks:—"*Poicilopleuron* was probably a semi-aquatic Dinosaurian, an animal equally capable of living on land or in water, and perhaps spending most of its time on shores or in marshes."*

But the cited capacity is enjoyed by *Crocodilia* equally with *Dinosauria;* and *Poikilopleuron* may well have spent, like its neighbour and contemporary the *Teleosaurus*, least of its time on shores or in marshes, if the latter were accessible to it in its Oolitic or Cretaceous localities.

The fossil described and figured by LEIDY adds nothing to the evidence previously extant of the affinities of *Poikilopleuron;* and if I plead for the retention of the orthography of the estimable discoverer of the genus, I more strongly protest against the addition of a new generic term for which LEIDY's fossil yields not a single character.†

The geological conditions under which Deslongchamps discovered his *Poikilopleuron* led him to remark: "aussi dut-il passer une grande partie de sa vie dans les eaux et probablement dans les eaux marines: puisque ses os sont restés dans un calcaire qui doit évidemment sa formation à des débris marins."‡

Amongst the rounded pebbles discovered in a position suggestive of their having been in the stomach of the *Poikilopleuron*, as such pebbles are commonly found in the stomach of a Crocodile or Alligator, Deslongchamps detected the tooth of a Cestraciont Fish,§ very significative of the element whence the *Poikilopleuron* derived its food.

Our actual knowledge of the skeleton of *Poikilopleuron* is sufficiently complete to give the answer to the question, "Whether the cavernous structure of its skeleton was related to pneumatic functions, as in Birds, flying Reptiles, and some others?"‖ The central cavity is completely closed; no pneumatic orifice or canal penetrates thereto: it had no communication with pulmonary or other air-cells. Nor is the alternative limited to marrow.¶ Primitive "chondrine," to which ossification had not extended, most probably filled the vacuity in the vertebral body shown at *d*, fig. 2, plate ii, of the 'Mémoires de la Société Linnéenne de Normandie,' sixième volume, 4to, 1838; as in figures of Plate 39, and in fig. 16 of Leidy's plate xv, op. cit.

* 'Contributions to the Extinct Vertebrate Fauna of the Western Territories,' p. 268, 4to, 1873.

† Ibid., pl. xv, figs. 16—18, "Antrodemus."

‡ Op. cit., p. 51.

§ Mem. cit., p. 65, "elle provient très-probablement d'une des derniers proies qu'il avait avalées."

‖ Id., p. 279.

¶ "Dans les deux séries, le corps des vertèbres est creusé d'une grande cavité médullaire (fig. 2 *d*, et v. *b*); le tissu spongieux n'existe qu'aux deux bouts; il y a de chaque coté, dans la gouttière laterale un trou pour le passage des vaisseaux nourriciers," p. 78; "ces vertèbres présentent à l'intérieure une grande cavité médullaire analogue à celle des os longs." Mem. cit., p. 83.

Family.—STEREOSPONDILIA.

Genus—Goniopholis.

Species—*Goniopholis simus*, Ow. *Crocodilia*, Pl. 40.

This species is founded upon the entire skull, *minus* the lower jaw, imbedded in the limestone of the Swanage quarry, of which skull a reduced view of the upper surface is given in Pl. 40, fig. 1; and of so much of the under surface (ib., fig. 2) as could be brought to light by exploratory operation on that part of the imbedding slab.

The skull in its general shape corresponds with the broad-faced species of the Procœlian Crocodiles;[1] and in the festooned contour of the alveolar borders, with those having teeth of unequal size, and with a crown of mainly the proportions of the teeth in the present Amphicœlian genus.

The conclusion conveyed by the latter expression is not, indeed, based upon the discovery of vertebræ in such contiguity with the present skull as to support an inference as to their having formed part of the same skeleton; but it is a probable one from the association of such vertebræ with the nearly allied species *Goniopholis crassidens* (*ante*, p. 427); and such probability is strengthened by the nature of the cranial modifications by which the skull under review differs from those of the Procœlian species most nearly resembling it in shape.

The temporal vacuities (ib., fig. 1, *t*) are relatively larger than in *Crocodilus* proper, or other broad-faced Procœlians, and are subquadrate in form. The palatonaris (ib., fig. 2, *n*) is not only larger, but is more advanced in position, so as to come wholly into view on the bony palate, and on the same plane therewith; and here, moreover, they receive, for completion of their anterior contour, the hinder ends of the proper palatine bones (ib., ib. 20), three fourths only of the border being contributed by the pterygoids (ib., ib. 24). The Eustachian aperture (ib., ib., *e*) is likewise on the palatal, not the occipital, plane.[2]

In these characters is manifested the nearer affinity of the Purbeck Crocodilian to the Amphicœlian Teleosaurs[3] than any Tertiary or modern genus presents.

The following are amongst the modifications of minor import in the skull of the present species of *Goniopholis*. The external nostril (Pl. 40, fig. 1, *n*), horizontal in position, is more nearly terminal than in modern Crocodiles, or than in *Goniopholis crassidens* (Pl. 11, fig. 1). It is formed by the premaxillaries exclusively; the nasal bones terminating about an inch behind the nostril. In Procœlian Crocodiles a graduated series of developments of the nasal bones can be traced. They may be short,

[1] Cuvier, 'Ossem. Foss.,' tom. v, part ii, pl. *i*, figs. 4 and 5.

[2] *See* 'Phil. Trans.,' MDCCCL, pl. xi, fig. 1 *e*.

[3] Ib., p. 522.

as in *Gavialis gangeticus*, or extend to near the nostril, as in *Crocodilus cataphractus*, rather nearer in *Crocodilus intermedius*, still nearer in *Crocodilus Hastingsiæ*, be produced close to the aperture as in *Crocodilus champsoïdes*, penetrate a short way into the aperture, as in *Crocodilus suchus*, or, by continuous ossification of the septum in old individuals of *Crocodilus niger* and *Alligator lucius*, extend seemingly across the nostril. These characters, barely of specific value, have been used in the fabrication of genera of existing Crocodiles and Alligators,[1] in all of which the orbits are larger than the upper temporal apertures. In *Goniopholis simus* the orbits (Pl. 40, fig. 1, *o*) are rather smaller than those apertures (ib., ib., *t*).

When p. 536 of the description of the Wealdon *Hylæochampsa* was printed off I had not materials for studying the palatal characters of *Goniopholis*. By excavating the under surface of the block of Purbeck stone on the opposite side of which the subject of Plate 40, fig. 1, was exposed, the characters in question were brought to light. A narrow medial tract, ib., fig. 2, *n*, contributed by both pterygoids and palatines divided the vacuity answering to Cuvier's 'Fosse nasal postérieure' in *Teleosaurus cadomensis*. An increase in the breadth of this pterygo-palatine septum gives the character of the '*palatonares*' (*Dinosauria*, Pl. 60, fig. 25, *s*, *s*) in *Hylæochampsa*, and removes any doubt as to the homology of those vacuities with the palatonares in *Goniopholis*. The pterygo-maxillary vacuities (Pl. 40, *y*, *y*) are relatively larger than in *Hylæochampsa*.

Each pterygoid (fig. 2, 24), articulating by a crenate suture with the narrow hind end of the palatine (ib. 20), which diverges from its fellow to form the fore part of the palatonaris, loses vertical thickness and gains in breadth as it extends backward. It there articulates by a tract of an inch in length with the basisphenoid. The Eustachian canal (ib., *e*) at the midspace between the basisphenoid and basioccipital. The latter arches down in advance of the condyle, and the venus foramen is conspicuous on this tract.

As the pterygoids are relatively less than in the Procœlians, so the palatines are relatively larger, especially in anterior breadth. After contributing their share to the palatonaris they come into contact, and the medial suture is continued forward to an extent of 3 inches 5 lines. The anterior breadth of the pair is 3 inches 4 lines. The medial suture of the palatal plates of the maxillaries was traced forward two inches or more in advance of the palatines, and laterally the plates were exposed to the same breadth as the palatines proper. The palato-maxillary suture, 20′—21′, is strongly sigmoid, describing as it leaves the midline a convexity forward and then a concavity. It was not thought expedient to endanger the unique specimen by further excavation in reference to the comparatively unimportant premaxillo-maxillary palatal suture.

The bony palate, as far as it was exposed, is smooth; the upper surface of the skull is rugose and pitted. The pits are circular or subcircular, from 1 to 2½ lines in diameter, situated chiefly on the swollen sides of the maxillaries and on the cranial part of the skull, including the expanded upper and outer surface of the squamosals; and

[1] 'Trans. Zool. Soc.,' vol. vi, p. 125.

the tympanic pedicles are smooth, and terminate in the usual transversely extended concavo-convex articular surface.

The tooth called "anterior canine" (ib., fig. 3, *i, c*) is preserved, somewhat mutilated, in each premaxillary. Sockets of smaller premaxillary teeth are faintly traceable. The tooth termed "posterior canine" (ib., *m, c*) projects from the anterior part of the out-swollen and convex border of the maxillary. From portions or traces of the other teeth or sockets I estimate that there were from sixteen to eighteen teeth on each side of the upper jaw. In the largest and least mutilated crowns of these teeeth the dental characters of the genus *Goniopholis* are shown.

In the 'Catalogue of the Osteological Series, Mus. Coll. Surgeons,' 4to, 1853, p. 164, is described the specimen No. 752, as "The skull of a Crocodile from Bengal wanting the lower jaw, of a species (*Crocodilus palustris?*) which is frequently found inhabiting the larger ponds. It differs from the *Cr. biporcatus* of the Ganges in having shorter maxillary and premaxillary bones in proportion to its length, and in having much less developed prefrontal ridges; the palatal suture between the maxillary and premaxillary bones is transverse, not curved. The anterior extremities of the palatine bones are narrower and more pointed. The number of alveoli is—premaxillary 5—5, maxillary 14—14."

The doubt indicated (?) arose from the inadequate characterisation by Lesson, of the species described by him in the 'Zoologie' of the 'Voyage aux Indes Orientales de Bélanger;' but there is no reference of the specimen, No. 752, to the *Crocodilus rhombifer*, as is affirmed by the author of the "Synopsis of the Species of Recent Crocodiles," 'Trans. Zool. Soc.,' vol. vi, p. 140. I did not regard my doubt as justifying the sinking of Lesson's "*palustris*" into a synonym, and of imposing a new specific, much less generic name. But the osteological character of the palatal region of the skull, pointed out in my 'Catalogue,' appears to be the chief of those relied upon by the author of that 'Synopsis' for his genus *Bombifrons*, of which the first character is:—"The premaxillary suture straight, or rather convex forwards" (loc. cit., p. 139). The other characters are not of specific value.

The sutures of the premaxillary bones, I may remark, are of three kinds; one is medial and unites the pair; it is the "interpremaxillary suture:" the second is lateral, uniting the outer or dental plate of the premaxillary with that of the maxillary; it is the "premaxillo-maxillary suture:" the third is transverse, more or less, and unites the palatal plate of the premaxillary with that of the maxillary; it is the "premaxillo-maxillary palatal suture." Its modifications, added to other differences, when determined to be constant, may aid in differentiating the species of *Crocodilus* proper, of *Alligator*, and of *Gavialis*.[1]

[1] Prof. Marsh, in his 'Introduction and Succession of Vertebrate Life in America,' 8vo, 1877, writes (p. 21):

"The beds of the Rocky-Mountain Wealden have just furnished us with a genuine "missing link," a

The convenience of these three genera of Procœlian *Crocodilia,* although they agree in palatonarial and vertebral characters, will probably ensure their retention; but *Tomistoma, Oopholis, Halcrosia, Palæosuchus, Rhynchosuchus, Ramphostoma, Mecistops. Bombifrons, Palinia, Molinia, Caiman, Jacare,* &c., into which they have been subdivided, exemplify the evil of "encumbering the science with a multitude of names" (loc. cit., p. 128),—an evil which, if the "names" do not represent "generic distinctions," cannot be laid to the charge of the "Palæontologist."

At least, the "small fragments of the fossil skeleton" (ib., p. 128) on which the genus *Goniopholis* was originally founded have subsequently been proved, by acquisition of other parts, to have indicated accurately that well-marked and interesting addition to the recorded modifications of the Crocodilian type. Those of the vertebral and cranial structures have, indeed, proved to be not only of generic, but of family value.

Genus—PETROSUCHUS, *Owen.*[1]

Species—*Petrosuchus levidens.* *Crocodilia,* Plate 41.

This genus and species of Crocodile is founded on the portion of skull and mandible, figured in Plate 41. The skull is imbedded in the same limestone of the Middle Purbecks, now quarried at Swanage. It was discovered in a block with the upper surface (ib., fig. 1) exposed. This surface is partially weathered, but shows here and there a faintly wrinkled natural sculpturing. The upper temporal apertures are larger than the orbits. In front of these the skull contracts more rapidly than in *Goniopholis,* and presents, as far as it is preserved, a slender form of face approaching to the proportions of that in the modern *Crocodilus cataphractus,*[2] and in the Tertiary *Crocodilus champsoïdes* (p. 115); but the more rapid contraction in front of the orbits is gavial-like, and there are other characters indicative of a nearer affinity than in *Goniopholis* to the Teleosaurian group. This affinity is decisively marked by the larger relative size and more advanced position of the palatonaris (ib., fig. 2, *n*), into the formation of which the diverging hind ends of the palatines (ib., fig. 2, 20) enter in a larger proportion than in *Goniopholis.* The basisphenoid (ib., ib., 5) is more produced, and the pterygoid (ib., ib., 24) contracts

Saurian (*Diplosaurus*) with essentially the skull and teeth of a modern Crocodile, and the vertebræ of its predecessor from the Trias."

When the cranial characters of this Crocodilian are made known it will be of moment to compare the temporal apertures on the upper surface and the palato-narial apertures on the under surface of the skull. When the dental characters of the same fossil are described and figured we may be able to determine whether they are those of the broad-faced procœlian Crocodiles and Alligators or those of *Goniopholis.*

[1] Gr. πέτρος, rock, and Σοῦχυς, an Egyptian name of the Crocodile.

[2] Cuvier, 'Ossem. Foss.,' 4to, tom. v, part ii, pl. v, figs. 1 and 2; Gray, 'Trans. Zool. Soc.,' vol. vi, pl. xxxii, fig. 2.

a more extensive sutural union therewith. Each palatine bone (ib., ib., 20), where they diverge at the palatonaris, shows a protuberance on its under surface. The Eustachian outlet is seen at *e*.

The portion of the left mandibular ramus (Pl. 41, fig. 3) includes the dentary element (32), nine inches in length, with portions of the angular (30) and surangular (29); that of the angular including six inches of its extent. Of this element two inches extend forward in advance of the hindmost point of the dentary; and, guided by the proportions of the *Crocodilus champsoïdes*, I estimate the total length of the mandible of *Petrosuchus levidens* to be 16 inches, or thereabouts, indicating that from four to five inches are wanting at the fore part of the upper jaw, the subject of fig. 1.

The vertical extent of the ramus behind the mandibular vacuity (ib., fig. 3, *v*) is 1 inch 9 lines; the vacuity itself is 1 inch 6 lines in long diameter, 6 lines in short diameter; its long axis is nearly parallel with that of the ramus. The lower, like the upper jaw, appears to have been long exposed on its imbedding block of stone. Little of the outer layer of the bone is preserved, and this is limited to parts of the angular and surangular. It here shows a more decided reticulate sculpture, the meshes being in the form of subcircular pits of from 1 to 2 lines in diameter.

The vertical breadth of the dentary at the terminal point of the angular is 1 inch 3 lines; it loses, as usual, in this diameter as it advances, but irregularly, owing to a gentle undulation of the alveolar border. This is convex where it supports the anterior group of teeth opposed to the premaxillary and foremost upper canine teeth; it is then slightly concave to the mid-third part, where the border is more feebly convex; beyond this, after a feeble concavity, it gradually rises to the surangular piece (29).

Of the foremost group of teeth seven are preserved; the third counting from the foremost being the longest and broadest, with the crown curving upward and a little backward; the length of this tooth is 1 inch 4 lines, its extreme breadth is 3 lines, about half of the total length forms the exserted crown, but the point is not entire. The first and fifth of this series are the next in size, but do not exceed an inch in length, the intermediate teeth are smaller; two or three sockets of still smaller teeth may be traced in the concave part of the border. In the following convex part, seven teeth are preserved, with shorter and relatively thicker crowns than in the foremost group; but none of them showing the robust proportions of the teeth of *Goniopholis*. Behind this group the indications of teeth and sockets are faint. I estimate the number of teeth in the present ramus at about twenty; which is the number in the mandibular ramus of *Crocodilus champsoïdes:* a margin of two or three more or less being allowed for a perpetually changing set of teeth.

The inequality of the size of the teeth and concomitant festooned course of their alveolar series is Crocodilian, as contrasted with the Gavialian and Teleosaurian types. But the temporal and palatonarial openings indicate the generic distinction of *Petrosuchus*, with its transitional character between the Teleosaurian and Tertiary Crocodiles.

Portions of dermal scutes, with the pitting as on the mandible, but with wider intervals, are preserved on the slab in which the above-described fossil is imbedded.

A few Wealden vertebræ, not associated with characteristic parts of any of the foregoing (pp. 431, 631, 634) *Crocodilia*, differ from those in Plate 10 by the carinate under surface of the centrum. They are figured in *Crocodilia*, Plate 14, under the provisional name of *Goniopholis carinatus*.

Of the known species of mesozoic Crocodiles, including the Purbeck and Wealden kinds now added, the following are common characters. A greater development, than in Tertiary Crocodiles, of the dermal bony armour, which consists, without exception, of both dorsal and ventral scutes, the scutes in each series well connected with each other, and in *Goniopholis* exceptionally so. A less development of the osseous surface for the origin of the muscles of the mandible indicated at the upper surface of the cranium by the larger 'temporal vacuities,' and at the under surface by the smaller pterygoid plates. The horizontal plane, larger size, advanced position and palato-pterygoid formation of the palatonares. Relatively small fore-limbs; Amphicœlian vertebræ in most, in none Procœlian.

These common characters of mesozoic *Crocodilia* suggest considerations of their relation to the prey of such *Crocodilia* and also to the coexistent marine reptiles of which those *Crocodilia* themselves became the prey.

Similarly, if the common characters of the tertiary and existing *Crocodilia* be summed up they become suggestive of analogous considerations. They are:—cup-and-ball vertebræ, the cup in front; fewer dermal scutes, not co-articulated suturally or by peg-and-socket joints; posterior aspect and position of small and exclusively pterygoid 'palatonares;' upper temporal apertures, when present, less than the orbits; fore-limbs relatively larger than in Amphicœlians; with one exception jaws stronger with larger and more varied teeth.

The Procœlian articulation of the trunk-vertebræ better adapts that part of the body to be sustained and moved in air than the Amphicœlian articulation which characterises the vertebral column of the more aquatic and probably marine Crocodiles of the Mesozoic period.

The presence of prey not in existence at those periods, but which in later, tertiary and modern times, might tempt a Crocodile to rush on shore in pursuit of a Mammalian quadruped, is a phenomenon contemporary at least with the acquisition of the Procœlian structure in the axial skeleton of such Crocodile.

The extent, the density, the closer fitting articulation of the bony scutal armature of the Mesozoic Crocodilians, suggests its use and need in waters tenanted at the same epoch by larger carnivorous marine reptiles, as, for example, the Ichthyosaurs, Plesio-

saurs, Polyptychodonts, and Mosasaurs. The oolitic species of Crocodile ('Crocodile de Caen.'[1]) is signalized by Cuvier as " l'espèce la mieux cuirassée de tout le genre."

But the *Goniopholis* of the Wealden and Purbeck formations surpassed even the *Teleosaurus Cadomensis* and its congeners in this part of its organization.

The great quadrangular dorsal scutes of *Goniopholis* are distinguished by the presence of a conical obtuse process continued from one of the angles transversely to the long axis of the scute, like the peg or tooth of a tile, which fits into a depression on the under surface of the opposite angle of the adjoining scute, thus serving to bind together the plates of the imbricated bony armour and repeating a structure which is characteristic of the large bony and enamelled scales of many extinct ganoid fishes.[2] The hexagonal ventral scutes of *Goniopholis* were firmly joined together by broad sutural borders. No knight of old was encased in jointed mail of better proof than these Crocodiles of an older world.

But the inimical contemporaries of those Crocodiles have passed away. No representative of Mosasaurian, Plesiosaurian, or Ichthyosaurian families lived after the secondary epoch. Crocodiles alone of the larger aquatic saurians continued on to the present times more fortunate than their predecessors in respect to possible hostile fellow denizens of the deep.

Certain it is that the defensive armour of Procœlian Crocodiles has degenerated. Bony ventral scutes are exceptional in them,[3] and the dorsal ones are fewer, thinner, less closely arranged and less firmly connected with one another. And if this change can be connected with the disappearance of *Reptilia* against the attacks of which a better coat of mail may have advantaged the contemporary Mesozoic *Crocodilia*, it may further be remarked that diminution of weight would favour Crocodilian movements in air, and that a loosely-jointed armour would less impede the evolutions required to catch a prey on land.

In this relation, also, arising out of the introduction in tertiary times of many species of warm-blooded Mammals frequenting the banks of lakes and rivers tenanted by carnivorous Alligators and Crocodiles, I have been led to ponder upon the well-marked difference in the relative position of the 'palatonares' (internal or posterior nostrils) which exists between the secondary and tertiary Crocodiles.

The physiologist discerns in the palatal and gular structures concomitant with the backward position and small size of the 'palatonares' in the existing Crocodiles and Alligators of Asia, Africa, and America, the power of holding submerged a powerful Mammiferous quadruped without the streams of water traversing the great cavity of the mouth during the struggle getting access to the posterior nostrils and windpipe of the amphibious assailant. The valvular mechanism applicable to, or, I may say, possible with, the

[1] Cuv., *Teleosaurus cadomensis*, Geoffr.

[2] "Report on British Fossil Reptiles," 'Reports of British Association,' 8vo, 1841, p. 70.

[3] Observed by Natterer in certain South-American Alligators, 'Beitrag fur näharen kenntniss der Süd-Amerikanischen Alligatosen Ann. Mus. Wien,' ii (1840), p. 313.

peculiar position of the posterior nostrils of Procœlian Crocodiles, opening vertically behind the bony palate, not horizontally upon that plane, could hardly be adjusted to the relatively larger post-palatine apertures, upon a horizontal plane at some distance from the occiput, with the inner nostrils opening at a more advanced position in the mouth, an arrangement which characterises all Amphicœlians.

No doubt there were sphincteric structures which would exclude water from the glottis in all the aquatic air-breathing reptiles, but the peculiar and well-developed valvular contrivances to that end in existing Crocodiles are conditions of the relative size and position of the posterior nostrils in them; and the repetition of that character in the palatonares of all known tertiary Crocodiles justifies an inference as to the concomitant valvular structures of the soft parts in those extinct Procœlian species, and their conformity with those in existing Crocodiles. These considerations stimulated or augmented the desire to determine the palatal characters of the fossil skulls of those *Crocodilia* of the newer Mesozoic formations which, in the massive proportions of their jaws, made the nearest approach to the tertiary and modern kinds. Such demonstration of the structure of the bony palate is accordingly given in the specimens of the Purbeck Crocodiles in the British Museum, described at pp. 632, 634, and figured in Plates 40 and 41.

Although the jaws of *Goniopholis crassidens* and *Goniopholis simus* have proportions adapted to grapple with large and active Mammals, the evidence of any such warm-blooded air-breathers co-existent with those Crocodilia is not yet acquired. And the probability of such co-existence is, in my opinion, very small, from the circumstance of the palatonares being relatively larger and more advanced than in the Crocodiles contemporary with great Mammals. The palatonares in *Goniopholis* open likewise upon a horizontal plane, look directly downward, not obliquely backward, and, moreover, have a different conformation. With this anatomical character, which I am disposed to associate with a fish diet, are combined in both *Goniopholis* and *Petrosuchus* upper temporal apertures larger than the orbits, and Amphicœlian or Amphiplatyan vertebræ. Now all known tertiary and existing *Crocodilia* combine with small, posterior, pterygoid palatonares, upper temporal apertures less than the orbits, and in some broad-faced kinds, the upper temporal apertures are almost obliterated by the progressive increase of the osseous roof of the temporal vacuities. These vacuities in the recent reptile are occupied by the temporal muscles, and the power of these biting and holding muscles is in the ratio of the extent of their bony origins.

In the Amphicœlian fish-eating *Crocodilia,* the upper temporal apertures are larger and usually much larger than the orbits; and they are, for the most part, associated with slender jaws and with numerous small uniformly-sized teeth.

With the palatine modifications, which relate to the drowning of air-breathing prey, and with the cranial developments which relate to the grip of such prey, we find, as a rule, in Procœlian Crocodiles, concomitant modifications in the breadth and strength of the jaws, and in the size of the teeth. There is also inequality of size, favouring hold-

fast, as in Mammalian *Carnivora,* and certain teeth of the dental series have accordingly received the name of canines in the *Crocodiles* with such analogous dentition. Partial developments of the alveolar borders concomitant with the modified dentition give a festooned course or contour to those borders.

In Mesozoic Crocodiles this character is exceptional and begins to appear at the Wealden period. The oolitic and older Amphicœlians have more numerous, smaller, and sharper teeth, occupying straight, or nearly straight, alveolar borders of the jaws. One genus, *Gavialis,* still exists, which exceptionally exemplifies the old dental fish-catching character.

Finally, in reference to the limb-character as distinguishing the *Amphicœlia* from the *Procœlia.* This character, at least, is exemplified in all the Mesozoic *Crocodilia,* of which the skeleton of the same individual has been sufficiently restored. It is then manifested by the shorter and smaller proportions of the fore pair of limbs as compared with the hind pair than we find in existing Crocodiles, and in the similarly restored skeletons of extinct Neozoic species (*Crocodilia,* Pl. 11).

The difference in question I take to relate to the more strictly or uniformly aquatic life of the Teleosauroids.

When the nilotic Crocodile darts under water after a prey, or swims off swiftly to escape a danger, the fore-limbs take no part in the action, but are closely applied prone to the trunk. The same motionless and unobstructive disposition of the fore-limbs has been observed in the still-surviving marine lizards of the genus *Amblyrhynchus.*

But the resistance to rapid swimming of fore-limbs so disposed is calculable according to the degree in which they break the uniformity of the curve and project beyond the surface of the fore part of the body to which they may be applied. The smaller, therefore, such limbs may be and the less will they obstruct the forward course of the Crocodile.

Thus, the Mesozoic Amphicœlians in their rush after fishes, or retreat from attacking larger Reptilia, would be favoured by their limb-character. On the other hand, their progress on dry land would be more difficult, unless, as has been suggested in regard to some kinds of Dinosaur with similarly stunted fore-limbs, the Teleosaurs were able to run upright on their hind-legs.

But dismissing such interpretation of the dwarfed fore-limbs of Mesozoic *Crocodilia,* to what conditions, it may be asked, do the augmented size and strength of these limbs in Neozoic Crocodiles relate?

The advent in tertiary times of large Mammalian quadrupeds browsing or prowling along the banks of estuaries and rivers haunted by such Crocodiles might, and does, tempt them to make a rush on the dry land to seize such passing prey. In such rushes the fore-limbs come into strenuous action.

A Lamarckian might say that this temptation to terrestrial locomotion would, by the repeated increased exertion and exercise of the fore-limbs lead, in the course of genera-

tions, to their augmentation of size, and he would set it down as one of the factors in the progressive transmutation of a Teleosaur into an Alligator.

His opponent would ask, of course, for the transitional forms. The subjects of the foregoing pages (631—636) in some degree represent such.

Those which I next proceed to describe also suggest relations of adjustment of characters to associated, probable, prey. Before entering on the descriptive details I may revert to the topic last discussed.

A large and powerful modern Crocodile having seized and submerged a tiger or buffalo, admits the water of the river it haunts into its wide lipless mouth by the spaces to which the thickness of the part of the prey gripped keeps asunder the upper and the lower jaws. Thus, the part of the mouth not occupied by the prey is filled with the fluid in which the mammal is being dragged and drowned. "The closure of the exterior nostrils"[1] would not prevent the water entering the 'glottis.' A special arrangement is requisite for this purpose, and such arrangement, as it exists in Neozoic Crocodiles, is incompatible with the relative position of "the posterior nares" and the glottis in the Mesozoic Crocodiles. The question is, with a closure of the external nostrils and the exclusion of water admitted by the mouth into the nasal passage, how is the water to be prevented from getting into the windpipe? We know how this is effected in the Cetaceans; and modern Crocodiles have as efficient a mechanism to the same end though on a different plan, but requiring a size and position of the palatonares which, as shown in previous pages, constitutes one of the best marked cranial characters differentiating the Mesozoic and Neozoic *Crocodilia.*

In all the Crocodiles contemporary with "large and active mammals"[2] there is a double valvular structure at the back of the mouth, which prevents the water having access to the mouth, from entering either the hinder nostril or the glottis. A membranous and fleshy fold hangs, like a curtain, from the hind border of the roof of the mouth, and answers to our 'velum palati:' the other valve is peculiarly crocodilian; it is a broad, gristly plate, which rises from the root of the tongue, carrying with it a covering of the lingual integument; and, when the palatal valve is applied to it, they form together a complete partition wall, closing the back of the mouth, between which and "the posterior nares" it is situated, shutting off both the latter aperture and the glottis from the mouth.

To make this mechanism available, the hind nostril is reduced in size, and such reduction is shown in the skull. The palatonaris is also placed far back, and its plane instead of being horizontal is tilted up at the angle which makes the operation of the two parts or folding doors of the partition most effective in closing the oral chamber posteriorly.[3] If the submergence of the Crocodile, with its large mammalian prey,

[1] 'Quart. Journ. of Geol. Soc.,' May, 1878, p. 429.

[2] Loc. cit., p. 425.

[3] 'Proceedings of the Zool. Soc.,' October 25th, 1831, p. 139.

should last so long as to render it needful for the reptile to take a fresh breath, it can protrude its prominent snout from the surface of the river, and inhale a current of air which will traverse the long meatus and enter the glottis by the chamber common to nose and windpipe, which is shut off from the mouth by the above-described structures. We have no ground for inferring this faculty and mechanism of soft parts from the bony palate in amphicœlian Crocodiles; the difference in its size and position are such as to have deceived both Bronn and De Blainville as to the position and homology of the palatonares in *Teleosaurus*.[1]

The subjects of the following sections bear unexpectedly, and in an interesting degree, on another objection, raised during the discussion at the Geological Society of London, on the topics treated of in pp 636—640. The objection was, that "warm-blooded animals did actually exist contemporaneously with the Mesosuchian Crocodiles."[2] As the only examples of the Mammalian class of which I was cognisant were the subjects of the undercited Monograph,[3] and a few other species of like diminutive size, it did not seem to me to affect a question exclusively bearing upon large Mammalian quadrupeds. It seems, however, that the Crocodiles which most abounded, if we may judge from the proportion of their fossil remains in the fresh-water deposits of the 'feather-bed' subdivision of the Purbeck series, were related in size to their contemporary diminutive Mammals. The Spalacotheres, Peralestes, Stylodons, Triconodons, &c., may well have been the prey of the dwarf Crocodiles of the locality. For these were reduced to dimensions which forbade them to disdain such succulent morsels, and at the same time they were suitably armed and limbed for the capture of the little Marsupials.

At the first aspect, detecting in the scattered groups of scutes in the Purbeck shales submitted to my inspection, specimens showing the peg (Pl. 45, fig. 3, *a*) and groove (ib., fig. 4, *b*), it seemed as if remains of some young specimens of *Goniopholis* were so exposed. The condition, however, of two of the skulls (Pl. 44, figs. 1 and 3) enabled a comparison to be made which determined their specific and, by their dentition, generic distinctions from both *Goniopholis* and *Petrosuchus*. The number of maxillary and mandibular specimens, of which several are figured in Pl. 44, exemplified a degree of constancy in size which begat a conviction that such was a character of the species; and, diminutive as were the Reptilia which have supplied the subjects of both plates, their characters were indisputably those of the Order *Crocodilia*.

One of them, by the size and shape of certain teeth, came nearer to *Goniopholis*, another by the same character resembled *Petrosuchus*, but the differential characters were such as could not have been obliterated by growth or age.

A third form of Crocodilian made a nearer approach in one of the species (Pl. 42, fig. 2) to the average size of the broad-faced genera. A fourth (ib., fig. 1)

[1] 'Abhandlungen über die Gavial-artigen Reptilien der Lias-formation,' fol., 1841, pp. 12, 16, 24.
[2] Hulke, J. W., 'Quarterly Journal of the Geological Society,' May, 1878, p. 428.
[3] "On the Fossil Mammalia of the Mesozoic Formations," Palæontographical Soc. Volume for 1871.

corresponded in size with the subject of fig. 2, but offered no character by which it could be legitimately removed from the genus *Goniopholis.* I commence with the description of this small but well-marked species.

Genus—GONIOPHOLIS, *Owen.*[1]

Species—*Goniopholis tenuidens,* Ow. *Crocodilia,* Plate 42, fig. 1.

The dental character of the Amphicœlian genus *Goniopholis* consists of the numerous close-set, fine, longitudinal ridges of the enamel, two of which, larger and sharper than the rest, traverse opposite sides of the tooth from the base to the apex of the crown, midway between the convex and concave lines of the curvature of the tooth, that is, at the fore and back parts of the crown.[2]

The general shape and proportions of the tooth-crowns indicate distinctions of species of *Goniopholis.* The type of the genus is characterised by the thickness and subcircular section of the crown, and the obtuseness of that in the posterior teeth.

In *Goniopholis simus*[3] the proportion of breadth to length of crown is less than in *G. crassidens,* and this difference is more marked in the specimen from the Feather-bed of Purbeck which forms the subject of fig. 1, Pl. 42.

This specimen consists of the chief part of the dentary and co-articulated splenial elements of both rami of the same mandible, partially dislocated at the symphysis. The alveolar tract includes the incisive (*i*) and molary (*m*) convexities, without an intervening laniary rising. The incisive convexity includes five sockets, a tooth being retained in the first, third, and fourth on the right, and in the first and third sockets on the left dentary. The foremost tooth has a crown of 6 mm. length and barely 2 mm. of basal breath; each has partially emerged from a socket larger than itself, and exhibits a portion of a tooth in succession to one which has been lost or shed. The socket is separated by an interval of 2 mm. from the second. This shows a subcircular aperture of 5 mm. in diameter. The third socket opens at 2 mm. distance from the second. The tooth (*b*) in the right dentary shows the inner, longitudinally concave side of the crown, with a basal breadth of 6 mm. and a total length of 16 mm. One may count about a dozen fine longitudinal linear ridges between the fore and hind stronger ones (ib., fig. 1 *b* and *b′*, magn.). The corresponding tooth (ib., fig. 1 *a*, magn.) in the left dentary shows the outer longitudinally convex side of the crown, with about sixteen fine ridges. These teeth answer to, or interlock with, the premaxillary or anterior canines of the upper jaw. The fourth tooth (ib. *c*) is less than the third; its crown projects 10 mm. from the right dentary; the fractured base of

[1] 'Reports of the British Association,' 8vo., 1841, "On British Fossil Reptiles," part ii, 1841, p. 690.

[2] Loc. cit., pp. 69, 70.

[3] Ib. ib., p. 7, pl. v.

the corresponding tooth in the left dentary is 4 mm. in diameter. Seven close-set sockets follow along the feebly concave part of the alveolar tract. The tooth of the twelfth socket at the beginning of the second convexity is preserved in both rami; its crown is 8 mm. in length, 4 mm. in basal breadth, with an obtuse summit, showing the feeblest indication of an apical point. This point is rather better seen in the crown of the next tooth, which has not wholly emerged.

The total number of teeth is sixteen in each of the dentary elements here preserved, and by analogy to the *Goniopholis simus*, the whole, or nearly the whole, of the dental series or sockets, in one dentary element is here exhibited.

The outer surface of the dentary is pitted by small subcircular, not close-set, impressions, except on the outer alveolar plate of the molary rising, where a few longitudinal pits indent the otherwise smooth surface of the bone.

The length of the symphysis is 25 mm., the depth 10 mm. The extreme breadth of the incisive part of the mandible is 32 mm.

The length of the preserved alveolar part of the dentary is 85 mm. (3 inches, 3 lines); the length of the entire mandible might have been between 5 and 6 inches.

Fragmentary evidences of the *Goniopholis tenuidens* in other slabs of matrix do not indicate any individual of a larger size than is exemplified by the above-described portion of lower jaw.

The mandible of *Goniopholis crassidens*, with an extreme depth of 4 inches, attained the length of 2 feet. Of this length the alveolar part of the dentary element occupied, as in most broad-faced Crocodiles, one half. The length of the alveolar part of the mandible of *Goniopholis tenuidens* being 3 inches, the total length of the jaw may be set down at one fourth of that of the type species of the genus.

Genus—Brachydectes, *Owen.*[1]

Species—*Brachydectes major*, Ow. *Crocodilia*, Plate 42, fig. 2.

In this genus and species a left mandibular ramus, 9 inches 6 lines in length, shows an alveolar tract of but 3 inches 9 lines in length. In the proportion of the jaw, therefore, appropriated to the lodgment of the teeth this Crocodile differs from the rest of the family. The ramus has a less relative depth than in *Brachydectes minor*, fig. 3; it measures in extreme vertical extent, taken at about one fourth of the length from the angle, 1 inch 9 lines, or little more than one sixth the entire length of the ramus, whilst in *Br. minor* the extreme depth of the mandible, which is about midway between the two ends, is nearly one fifth of the entire length of the ramus. This proportion might, however, be deemed an immature character of the smaller specimen, but there are

[1] Gr. βραχὺς, short; δηκτὴς, biter.

other differences in the jaw of *Brachydectes major* not attributable to age and consequent growth. There is no longitudinal ridge on the angular element. The angle itself is more produced. This process repeats, indeed, the low position characteristic of the genus *Brachydectes*, but the line descending thereto from the articular element is straight, not concave, as in *Br. minor*, and the curve from the angle to the convex border of the angular element (fig. 1, 30) is deeply concave. Moreover, the outer surface of the deep hinder part of the ramus is sculptured with close-set deep pits, giving a strongly reticular character to that part of the bone.

The alveolar tract shows, as in *Brachydectes minor*, a laniary convexity (*l*) as well as an incisive one (*i*); both, however, are slight. In the latter the crown of the third or fourth incisor is preserved; it is 20 mm. in length, 6 mm. in basal breadth. The enamel of the exposed outer side is smooth; the fore part of the crown is obtuse, the hind part trenchant, with a faint appearance of minute denticulation. This is the only tooth preserved in the present jaw. There are faint indications of ten or twelve alveoli behind the tooth; two of these in the laniary curve (*l*) indicate teeth proportionally as large as the canine in *Brachydectes minor*. The outer surface of the laniary convexity is smooth. The rugged irregularly and minutely pitted character is continued to the alveolar border of the incisive convexity. The sutures between the dentary and hinder elements of the mandible are not clearly definable. Certain parts of the outer surface which were wanting made it doubtful whether any vacuity between the surangular, angular, and dentary elements existed; and the condition of the jaw of the smaller species weighs in favour of assigning an uninterrupted outer wall of the mandible as an additional differential character of the genus.

The proportion of the incisor tooth approaches that of the third in *Petrosuchus*,[1] but the latter is longer in proportion to the basal breadth. The dental series, and consequently the dentary element, are relatively longer in *Petrosuchus* than in *Brachydectes*.

A second specimen of the left dentary bone repeats closely the same size and characters of the corresponding part of the mandibular ramus above described. The teeth are wanting. Behind the alveolus of the 'anterior canine' are indications of seven or eight following alveoli, not more. The better preserved outer plate of the bone demonstrates the absence of the vacuity which is present in *Petrosuchus, Goniopholis*, and *Crocodilia* generally.

Species—*Brachydectes minor*, Ow. *Crocodilia*, Plate 42, fig. 3.

This species first indicated the genus in the exploratory operations; it is represented by the left mandibular ramus (Plate 42, fig. 3), which is remarkable, as in the larger species, for the small proportion which the alveolar tract bears to the entire length of the

[1] P. 634, Pl. 41, fig. 3.

bone, and for the entireness of the outer wall. The alveolar tract is undulated, showing an incisive and a laniary convexity with intervening and hinder concavities.

The incisive convexity holds five teeth, close set, the two hindmost rather larger than the rest; but no single tooth is so much larger as to suggest the name of 'canine.' The laniary convexity shows one large canine with a broad, straight, laterally compressed crown. It is preceded by a smaller tooth, rather less than the hindmost incisor, and separated therefrom by a space which may have held two or three small teeth. The alveolar tract behind the canine seems to have lodged three or four teeth, the crowns of which are lost.

The whole length of the alveolar tract is 23 mm. (1 inch); that of the entire ramus is 85 mm. (3 inches 2 lines). The dentary element bifurcates behind as usual; the upper prong joining the surangular, the lower and longer one the angular, but without defining or leaving any vacuity; the union where such vacuity would have been left in ordinary Crocodiles is situated well within the anterior half of the ramus. The posterior elements are correspondingly of unusual length; their breadth is also proportionally greater than in previously known Crocodilian mandibles. The length of the surangular element (29′) is 48 mm. (1 inch 10 lines); its depth (vertical breadth) is 13 mm. (6 lines). The upper border describes a feeble convexity; beneath the articular surface of 29 the surangular curves downward and backward, meeting the lower border at a point wedged between the articular and angular elements.

The articular exposes the outer antero-posterior concave border of the joint. From this it descends obliquely backward and joins the angular in forming the process (30′), which here projects directly backward, its termination being much below the joint, and nearly on the level of the lowest part of the lower border of the jaw. The angular element extends forward from the angle, with its lower border at first straight or feebly concave, and then moderately convex to its junction with the dentary; a ridge projects along the greater part of this course a little way above the lower border. A portion of the splenial element shows above the fore part of the surangular, and supplements the inner alveolar wall at the hind part of the dentary.

From the lower jaw of *Theriosuchus* (Plate 44, figs. 5, 14, 16) the present differs in the shortness of the dentary element and alveolar series, in the greater depth and verticality of the outer surface of the ramus, and the narrower inferior border. It also offers a generic distinction in the number and shape of the teeth.

The proportional length and slenderness of the dentary and the absence of any laniary convexity succeeding the incisive one, together with greater number and the shape of the teeth of *Nannosuchus* (Pl. 43, figs. 8 and 9) offer a more striking contrast with the mandible and teeth of *Brachydects.*

No specimens have been brought to light which show characters of *Brachydectes minor* on a larger scale than is represented by the mandibular ramus above described.

Genus—Nannosuchus,[1] *Owen.*

Species—*Nannosuchus gracilidens*, Ow. *Crocodilia,* Plate 43, figs. 1—10 ; Plate 44, figs. 1 and 2.

In this genus the teeth have long, slender, sharp-pointed crowns, slightly recurved, mostly sub-circular in transverse section, impressed by a few linear or narrow and shallow grooves. The dental series is pretty uniform as to size and shape of crown, but less so than in the Teleosaur and Gavial; the teeth are also less numerous and wider apart.

The claim to generic distinction indicated by the armature of both upper and lower jaws was established by an additional dental character revealed in the following specimen.

The fore part of the mandible (Plate 43, fig. 1) exhibited a tooth *in situ* (fig. 1 *c* and fig. 2 enlarged), answering to that termed the 'anterior canine' in *Crocodilia*, but presenting characters which I had not before observed in those or other *Reptilia.*

The crown is long in proportion to the basal breadth, conical, recurved, and pointed. It is traversed along the middle of the outer surface by a ridge, or rather a low angle of the enamel, simulating a ridge; between this and the trenchant hind border is included one third of the outer surface of the crown. This tract is smooth, and, transversely, is feebly depressed or concave, giving a trenchant character to the hinder longitudinally concave edge of the crown. The two thirds of the outer, transversely convex, surface of the crown is traversed by close-set linear grooves, and intervening ridges, which mostly subside at the apical half of the crown, leaving about one third of the apex smooth. This tooth appears to be the fourth counting backward; the length of the crown is 10 mm., the basal breadth 3 mm. An enlarged view is given of the outer side of the crown in fig. 2.

The foremost tooth, also preserved (fig. 1, *i*), shows a coronal length of 5 mm., a basal breadth of 1 mm.

The crown of a fifth tooth rises close behind that of the fourth, with a basal breadth of 2 mm, and a length of 5 mm.; it is conical, but is straight. The outer side, uniformly convex, is traversed along the basal half by fine ridges and intervening grooves; it may be that the whole of this crown has not emerged.

The portions of mandible, the subject of fig. 1, consist of the right and left dentary elements, of which the major part is preserved, the rest indicated by impressions on the matrix. The preserved parts include the symphysial expansion, the joint being slightly dislocated through pressure, which has acted obliquely. The right dentary shows its outer side, the left dentary its lower border, and beyond the symphysis a small proportion of the outer surface, while the inner one is partly covered by the smooth splenial element (31).

[1] νάννος, dwarfish, Σοῦχυς, an Egyptian name of the Crocodile.

The breadth of the symphysial part of the right dentary is 15 mm.; the length of the under part of the symphysis is 18 mm. At 33 mm. from the fore end the (vertical) breadth of the ramus diminishes to 10 mm., beyond which it gradually increases to 15 mm., where the bifurcation of the bone begins. The entire length of the part preserved is 114 mm. (nearly $4\frac{1}{2}$ inches).

The exterior of the symphysial part of the dentary is pitted by numerous minute subcircular depressions. As the bone contracts the depressions enlarge and elongate, then take the form of longitudinal grooves of irregular depth; but these become limited to the lower half of the outer side of the dentary, the part above, which forms the outer alveolar plate, being smooth, with a few faint, short, longitudinal linear impressions.

The symphysial expanse of the right dentary shows five sockets, of which, as above stated, the first, fourth, and fifth retain their teeth. The implantation of these teeth in complete sockets confirms the indication by the sculpturing of the bone that the jaw has belonged to a member of the Crocodilian order.

The first tooth was the smallest; the second and third, judging from the sockets, gained in size; the fourth is the largest, and represents, as above remarked, the tooth opposing or interlocking with the premaxillary canine above; the fifth abruptly loses size. Of the succeeding teeth little more can be divined from the present specimen than that they were small or, at least, slender. The convex curve, lengthwise, of the outer alveolar border is very feeble, and seems to have helped to lodge the hinder teeth; it is divided by a long feeble concavity from the symphysial or incisive convexity. There is no laniary rising.

Two smooth bones (31, *x*) contribute to the inner wall of the ramus, as exposed on the left side. If the lower one (*x*) represents the splenial, the upper one (31) would be an unusually developed inner plate of the dentary. If this, however, should be, as its posterior expansion indicates, according to the analogy of the modern Crocodiles, the splenial element (31), then the lower bone (*x*), would represent an angular element unusually produced forward. The longitudinal line of demarcation between these smooth inner questionable elements is not an accidental crack.

The Crocodilian character of the present jaw is supported by the scutes (Pl. 43, fig. 4) and impressions (fig. 5) of scutes, by a vertebra (fig. 3), by portions of ribs with a bifurcate proximal end, and by a metacarpal bone, all on the same slab of matrix.

The vertebra is Amphicœlian; the neurapophysial suture is unobliterated; it is from the part of the trunk where the rib articulation has risen wholly above the centrum. This element is 13 mm. in length; the non-articular surface is smooth and entire, gradually and slightly expanding to the articular ends; the one exposed being subcircular, 10 mm. in diameter.

Of the scutes preserved the largest are oblong, quadrangular, with a tooth-like process from the anterior and outer angle, from the base of which is continued a raised

smooth tract along the anterior border, from 4 to 3 mm. in breadth. The breadth of the entire scute is 17 mm.; the length is 35 mm. Some smaller scutes are pentagonal.

We have here, therefore, evidence of an Amphicœlian Crocodile, with the dermal armour after the type of that of *Goniopholis*, but generically distinct by the characters of the mandibular dentition. If the dentary bone constituted three fourths the length of the mandible this may be reckoned to have been about 6 inches in length, and the entire Crocodile may have been 6 feet in length.

The portion of mandible of which the under surface of the dentary and splenial elements are exposed, forming the subject of fig. 6, Plate 43, is shown by certain teeth in place and others scattered near in the same slab, to belong to the same genus and species as that represented by fig. 1, and to have come from an individual of similar size. Both are the largest evidences of *Nannosuchus* shown in the numerous series of Reptilian fossils from the portions of the 'Feather-bed' formation now under review.

The symphysis, 21 mm. in longitudinal extent, forms a fifth part of the preserved extent of the dentary; the breadth of this part of the jaw is 30 mm.; that behind the symphysis is 27 mm. The rami, as far as they are preserved, diverge to a breadth of 70 mm.

The alveolar part of the symphysis describes an incisive convexity, and the sockets indicate one or two teeth of larger size and thicker proportions than those of the rest of the dental series. The crowns of two of these teeth, which had become detached, are fortunately preserved, near the fore part of the jaw. The largest (fig. 7, magn.) represents the 'anterior canine,' and is the homologue of fig. 1 *c* and fig. 2, magn. It shows the well-marked characteristics of that tooth in *Nannosuchus*, and, besides the difference of sculpturing, the crown is more strongly curved than in *Goniopholis* or *Petrosuchus*. The second detached tooth near the incisive alveoli shows both root and crown. The latter is but half the length of that of the 'canine;' more of the convex side is exposed than in fig. 2; it is traversed by fine longitudinal ridges. The teeth which are in place show a smaller size and more slender pointed crown. There is no evidence of any tooth equalling in size the largest of the symphysial or incisive series.

The numerous minute circular pits sculpturing the symphysial expansion change, as in the specimen (fig. 1), to coarser and larger longitudinal impressions as the rami recede and pass backward; and the surface near the alveolar border showing the feeble molary convex curve is smooth.

The dental character of *Nannosuchus* is more fully exemplified by smaller specimens, of which two, forming parts of the lower jaw, will be first noticed.

The subject of fig. 8, Pl. 43, includes the dentary and angular elements, partially dislocated, of the right mandibular ramus. Two of the molary series of teeth are *in sitú*, showing long, slender, feebly recurved crowns, each 5 mm. in length; other teeth of similar shape and with finely striate enamel are on the same slab.

In a smaller dentary (Pl. 43, fig. 9) the sockets of eighteen teeth are visible. The proportions and outer markings agree with those of the larger specimen.

The humerus (fig. 10), preserved near the jaw, shows the usual Crocodilian characters, with more slender proportions than in *Crocodilus niger;* it rather resembles that of the Gavial.[1]

The characters of *Nannosuchus* yielded by the foregoing specimens are supplemented by those of the skull represented of the natural size in Pl. 44, fig. 1. The teeth preserved *in sitû* and detached, but in contiguity with the alveolar border, are generically those to which they would be opposed assuming the skull to be that of a *Nannosuchus.* The inferiority of size is not shown by any other distinctive character to indicate a species other than that founded on the lower jaws above described.

As in those, the teeth of the upper jaw are divided by intervals usually greater than their basal breadth. Each premaxillary (fig. 1, 22) had four teeth at least; the maxillary had not fewer than ten teeth.

The characters of length and slenderness of crown in the teeth of this small Crocodile suggested a comparison of its skull with that of *Petrosuchus*, but the differential characters exceed in importance those of size. The upper jaw of *Nannosuchus* does not contract so rapidly, or in so great a degree in advance of the orbits, as in *Petrosuchus* (Pl. 41); it is also shorter as well as broader; no amount of growth could have converted it into the slender elongate shape which approximates *Petrosuchus* to the gavial-like *Crocodilus cataphractus.*

The hind border of the parieto-mastoid platform is undulate; gently convex at the middle, where it is formed by the parietal (ib., 7), concave on each side, where it is carried out by the mastoids (ib., 8).

In *Crocodilus niger* this border is straight; in *Croc. palustris* it is undulate, but the middle parietal convexity is much less than the lateral, concave, mastoidean curves, owing to the relatively narrower extent of the parietal bone. The lateral borders of the supra-cranial platform, due to the mastoids (ib., 8) and post-frontals (ib., 12), present, in *Nannosuchus*, a gentle sigmoid curve. In most modern *Crocodilia* these borders are straight, running parallel in *Croc. niger*, slightly convergent forwards in *Croc. cataphractus* and *Croc. intermedius.*

The breadth of the platform is to that of the skull, taken across and including the zygomatic arches, as 8 to 10 in *Nannosuchus;* in *Croc. niger* the platform is little more than half the breadth of the skull taken across the hind part of the parieto-mastoid or upper temporal apertures; in *Croc. palustris* the platform occupies half the breadth of the skull taken at the same part.

The upper temporal apertures (T) have the same relative size as in *Petrosuchus*, but they differ in shape, being less circular, the longer diameter being longitudinal, or in the skull's axis. As far as the orbits are preserved these do not exceed in size the upper temporal apertures. This character of the Mesozoic Crocodile is retained in the present dwarf species. A super-orbital bone strengthened the upper eyelid; it retains

[1] 'Catalogue of Osteology, Mus. Coll. Chir.,' 4to, 1853, p. 153, No. 691.

its connections with the frontal (11), post-frontal (12), and pre-frontal (14) in the left orbit (*o*); but has become slightly detached in the right orbit (*o'*). The nasal bones (15) terminate in a point distant from the external nostril by rather more than the diameter of that aperture, which accordingly is single and exclusively bounded by the premaxillaries. In this character *Crocodilius cataphractus* and *Croc. intermedius* resemble *Nannosuchus;* but the upper jaw is longer and more slender in proportion in both these existing Crocodiles than in the Purbeck species; in both, also, the upper temporal apertures are relatively smaller than in *Nannosuchus.*

In the character of the nasal bones and conformation of the external nostril *Nannosuchus* resembles *Goniopholis* (Pl. 40), but the supra-temporal apertures are more oblong and the maxillaries are not so out-swollen as they approach the premaxillaries. The facial part of the skull, from the front border of the orbit forwards, equals the extent of the skull from the same part to the occiput in *Nannosuchus;* in *Goniopholis* the facial part of the skull, so defined, is one third longer than the extent behind. The mutilated state of the unique skull of *Petrosuchus* prevents a similar comparison being made.

The sculpturing of the upper surfaces of the exposed parts of the skull in *Nannosuchus* presents the common Crocodilian character of minute subcircular pits, leaving a reticulate disposition of the intervening bone.

Genus—THERIOSUCHUS,[1] *Owen.*

Species—*Theriosuchus pusillus,* Ow. *Crocodilia,* Plate 44, figs. 3—18; Plate 45.

This Crocodile, somewhat smaller in size than the preceding species, approaches nearer to the type of the broad-faced Alligators in the proportion of the antorbital part of the skull.

The dentition is more modified than in any other known Crocodile, recent or extinct, and approaches that which characterises the Theriodont order of Triassic Reptilia.

The premaxillary teeth are five in number in each bone; the three middle ones subequal, the first and fifth smaller. The maxillary teeth are divisible into laniaries and carnassials or trenchant molars. The first maxillary tooth is small (Pl. 44, fig. 5); the second and third gain quickly in size, the latter (*a*) assuming the character of a canine; the fourth tooth (*b*) is a still larger canine; the fifth (*c*) and sixth (*d*) decrease in size somewhat suddenly, but in length rather than breadth of crown, and terminate the series projecting from the convex part of the alveolar border of the maxillary. The tooth *c* or *d* may be said to terminate the laniary series. Beyond *d* the teeth lose length and slightly gain in breadth; the crown assumes a triangular, laterally com-

[1] Gr. θηριον, wild beast; σοῦχος, crocodile.

pressed, or lamellate form, and the enamel is transversed on the outside by fine but distinct lines (ib., fig. 6, *e*). Of these sectorial or carnassial molars some of the detached specimens of maxillary (figs. 7 and 11) indicate as many as eight or nine. The broad base or root of each tooth is not inserted into a separate and complete socket, but is lodged in a recess of the outer alveolar wall; moreover, the partitions between these recesses are low or partial, and the teeth appear to have been applied thereto, without being so completely confluent therewith, as in the pleurodont mode of fixation of the teeth in certain Lizards. Hence, in some of the specimens of the maxillary bone the incisors and canines only are retained, being rooted each in its own complete socket; while the molars have fallen out, and their partially separated recesses are shown, as in figures 7 and 11.

In the lower jaw the foremost tooth is rather larger than those which interlock with the middle premaxillary or 'incisor' teeth above; but not any of the succeeding laniary teeth attain the size of the upper canines. The twelfth tooth, counting backwards, assumes the lamellate, triangular shape of striate crown characteristic of the superior sectorials; and the inferior ones were lodged, like those above, in a common depression of an outer alveolar wall, developing the ridges dividing such depression into the dental recesses, as shown in fig. 16, Pl. 44. This approximation to a Lacertian dental character might seem ground for something more than a family section of the order *Crocodilia;* but the quasi-pleurodont attachment of the hinder teeth in *Theriosuchus* is only an extension of the character affecting some of the teeth in existing species of Crocodile.[1]

In the cranial platform of *Theriosuchus* the medial parietal part of the hind border is less convex and the two outer parts are more concave by reason of the further backward production of the mastoids than in *Nannosuchus*. The lateral borders of the sculptured part of the platform are more convex than in that genus. This is owing to the greater proportion of the outer and posterior angles of the platform which is abruptly depressed below the level of the sculptured surface of the mastoid, and which becomes smooth like the contiguous and lower-placed tympanic. This character, shown in the subject of fig. 3, Pl. 44, usefully indicated fragmentary parts of the skull of other individuals of the species, such as are figured in fig. 1, 12′, Pl. 45. The supra-temporal vacuities are relatively larger than in *Nannosuchus*. The intervening tract of the parietal, rather more canaliculate than in *Nannosuchus,* is divided by a mid ridge in two of the cranial specimens, and partially so in the more complete skull.

No palpebral ossicle is preserved in the orbit (*o*). The pointed ends of the nasals are produced so as to divide the outer nostril into two, as in some specimens of *Crocodilus*

[1] It is noted in the *Alligator niger*. "No. 765. The right ramus of the lower jaw, from which the posterior part of the inner alveolar wall has been removed, showing the five posterior teeth lodged in a common alveolar groove." 'Osteological Catalogue, Museum of the Royal College of Surgeons,' 4to, vol. i, p. 167 (1853).

niger; were this a character of generic value, it might unite *Theriosuchus* with *Halcrosia*, Gray.[1]

The alveolar part of the maxillary in which the canines are developed make a corresponding convex extension of its outer border, as in *Goniopholis.*

The extent of the 'symphysis mandibulæ' and the angle of divarication of the rami are shown in fig. 4, Pl. 44.

The matrix was removed as far as practicable from the palatal surface of the skull (fig. 4) and exposed a portion of the basisphenoid (5), of the pterygoids (24), of the palatines (20), and palatal plates of the maxillary (21); the pterygo-maxillary vacuities (*y*) and the hind portion of the palatonares (*n*) were brought into view. What seems to be a portion of the hind part of a mandibular ramus was so wedged down upon a part of the palatal surface that, in regard to the fragile character of this unique skull, it was deemed unadvisable to attempt its removal.

In Pl. 45 a portion of the skeleton of *Theriosuchus pusillus* is figured. It is of one individual. In the slab of matrix in which it is imbedded the fore part, marked A, A, is continued on from the hind part with an interval of the extent marked B. At this interval the slab has been broken across, but the parts appear to have been naturally readjusted before the specimen was fixed in its present frame. The position in which the two portions of the skeleton are figured relates to the convenience of size of the Plate.

The skull has been displaced and fractured, but the contiguity of the preserved portion with the vertebral column supports the conclusion that it formed part of the skeleton of the same individual. It thus serves to determine the species to which the subject of Plate 45 belonged.

The part of the skull includes the parieto-mastoid platform (7, 12′) with the tympanic (28) and the squamosal (27). The articular surface of the tympanic for the mandible shows the Crocodilian character. The median or sagittal ridge of the parietal is well marked, and is continued along the mid-frontal. This character is partially effaced by mutilation in the more entire skull (Pl. 44, fig. 3). It is well shown in the frontal bone indicating the largest of the specimens of *Theriosuchus* (ib., fig. 8).

The vertebral centrums of the trunk show the shallow Amphicœlian character of those of the *Goniopholis* and Teleosaurians. The smooth under or dermal surface of part of the two median rows of the dorsal scutes are shown in the fore half of the skeleton. In the hind half the upper or epidermal surface of the scutes is exposed, showing in most the submedial longitudinal ridge. This is wanting in certain, probably lateral, scutes, of which a group is exposed at the fore part of the anterior portion of the skeleton. One of these unridged, but toothed, scutes is figured at fig. 3, Pl. 45.

Of the limb-bones preserved may be recognised the right scapula (51) and humerus (53), the left humerus (53) with the radius (54) and ulna (55), followed by some dislocated

[1] 'Trans. Zool. Soc.,' vol. vi, p. 135.

metacarpals and phalanges of the fore-foot. In the hind portion of the skeleton (fig. 2) the right femur (65), tibia (66), fibula (67), with the four metatarsals and scattered phalanges, are preserved.

All the limb-bones show the ordinal Crocodilian characters, but the proportion of the fore to the hind limb is that of the Procœlian division, not that of the Teleosaurs.[1] In this respect, as in the proportions of the maxillary bones and teeth, the advance to Tertiary types of Crocodilia is manifested. As in these the *Theriosuchus* was better adapted for locomotion on dry land than were the Teleosaurs.

In *Theriosuchus* the breadth and shortness of the antorbital part of the skull in proportion to the part behind exceeds that in any modern broad-snouted Crocodile. Even in the young 'Crocodile à deux arrétes,' figured in Pl. I of Cuvier's 'Ossemens Fossiles,'[2] a transverse line across the fore part of the orbits equally bisects the skull, omitting the mandible. In *Theriosuchus* the same line leaves in advance six thirteenth parts of the length of the skull.

This proportion suggested at first view the immature state of the individual to which the subject of fig. 3, Pl. 44, had belonged; but of the numerous evidences of *Theriosuchus pusillus* none were larger than those figured in Pl. 45, and in figs. 3, 4, 8, 14, 16, of Pl. 44: several other fragmentary evidences had come from smaller individuals.

I conclude, therefore, that, as in the case of most species notable for their diminutive size, immature characters of the larger species of the genus are associated with such dwarfishness of the adults. The only known mammals of the Purbeck period characteristic, moreover, like the dwarf Crocodiles, of the fresh-water 'Feather-bed' deposits, are of diminutive size, and the carnivorous Saurians seem to have been thus adapted in dimensions and force to their prey.

I estimate the average length of a mature *Theriosuchus* at 18 inches. The length of the skull, taken as that of the mandible, is 3 inches 6 lines. In the articulated skeleton of a modern Crocodile the angle of the lower jaw extends to the third cervical vertebra. In *Alligator lucius* the trunk from the third cervical to the last sacral vertebra inclusive is nearly equal to two lengths of the skull; the length of the tail is $2\frac{1}{3}$ lengths of the skull. The trunk of *Theriosuchus* so defined includes two lengths of the skull. The tail, as indicated by fig. 2, Pl. 45, equalled $2\frac{1}{3}$ lengths of the skull.

In the long-jawed Gavials and Teleosaurs the trunk includes about $1\frac{1}{4}$ length of the skull; but the tail is proportionally longer than in the short- and thick-jawed Crocodiles.

[1] *Crocodilia*, Pl. 11.

[2] Quarto, tom. v, 2de partie.

Crocodilian Vertebræ. Plate 42, figs. 4—12.

Of the numerous scattered vertebræ in the different slabs of the Purbeck matrix those specimens have been selected for figuring which exemplify the Crocodilian characters of different portions of the vertebral column.

The subject of fig. 4, Pl. 42, is from the neck or fore part of the trunk, in which the hypapophysis (*hy*) has not subsided on the under surface of the centrum ; the processes for the head ('parapophysis,' *p*) and tubercle ('diapophysis,' *d*) of the proximally bifurcate rib are well developed. The pre- (*z*) and post- (*z'*) zygapophyses, together with the neural spine (*n. s.*), complete the series of developments of this complex type of Crocodilian vertebræ.[1]

Figs. 5 and 6 are two consecutive, but slightly dislocated, vertebræ from the hinder part of the trunk. The long and broad diapophyses show the notch (*d*) where the simple and short hinder ribs were articulated, each by a single joint, with the rest of their osseous 'segment' or vertebra.[2]

Figs. 7 and 8 are side views of mutilated hinder trunk vertebræ.

Fig. 9 gives a back view of one of the sacral vertebræ, showing the robust processes represented by coalesced pleurapophyses. The suture is traceable by which the latter articulate with both centrum and neural arch.[3]

Fig. 10 is a caudal vertebra, with the hæmal arch and spine (*h*) ; a front view of the latter is given in fig. 11 ; the vertebra is from that part of the tail where the pleurapophyses cease to be developed.[4]

Fig. 12 shows the completely ossified substance in a section of a dorsal centrum.

Fig. 13 probably belonged to *Brachydectes minor*.

All these and other detached vertebræ indicate the dwarfed proportions of the *Crocodilia* characteristic of the fresh-water deposits of the 'Feather-bed.' Many correspond in size and shape with those shown *in sitú* in *Theriosuchus*, Pl. 45. The subjects of figures 4—10 I am disposed to refer to *Nannosuchus*.

Crocodilian Scutes. Pl. 43, figs. 4, 5, 11, 12.

In almost every slab containing Crocodilian remains are scutes, or portions or impressions of scutes. They include the 'peg-and-groove' type, the hexagonal with

[1] No. 687, 'Catalogue of Osteology,' 4to. *ut supra*.

[2] No. 689, op. cit., p. 153.

[3] It accords with the character of the sixth cervical vertebra in *Gavialis gangeticus* ('Catal. of Osteology, Mus. Coll. Chir.,' 4to, vol. i, p. 152, No. 684), save in the minor devolopment of the hypapophysis, which indicates a position in the vertebral column somewhat further back.

[4] See No. 686 of the same series and 'Catalogue.'

sutural margins, and the ordinary quadrate with bevelled edges, either plain or single-ridged. All show the Crocodilian pitted or reticular sculpturing on one side, the smooth surface on the opposite.

The scutes exemplified in Plate 43, figs. 4 and 5, partly by portions, partly by impressions, may be referred both by contiguity and proportional size to the larger examples of *Nannosuchus gracilidens*. Some scutes of this type, of rather larger size, and with the smooth, overlapped, anterior border relatively broader and more elevated than in *Goniopholis crassidens*,[1] may belong to the smaller species of *Goniopholis* (*G. tenuidens*) or to the larger kind of *Brachydectes*. A smaller-sized peg-and-groove scute would fit *Brachydectes minor;* the smallest and most numerous of all are commonly associated with evidences of *Theriosuchus pusillus*.

The most instructive scutal fossils are those which exemplify the relative position and mode of interlocking of the articular mechanism. Of these are figured two groups, one showing the outer (ib., fig. 11), the other the inner (ib., fig. 12) surfaces.

These specimens afford grounds for additions to the original description of the peg-and-groove modification of Crocodilian armature.

To the "process continued from *one of the angles* vertically to the long axis of the scute"[2] may be added "from the anterior and external angle;" and for "the depression on the opposite angle of the adjoining scute" may be written "on the under surface of the posterior and external angle of the scute in advance."

When the medial dorsal series of scutes are seen in natural connection from the outer surface the articulating peg is concealed, as in the two hinder pairs of the three shown in fig. 11, Pl. 43. When the inner surface of a similar series is exposed, as in fig. 12, the mode of application of the pegs and grooves comes into view.

The scutes of the two medial rows along the back of these Purbeck Crocodiles join each other at the medial line by a close contact of the inner borders—a kind of 'harmonia' or toothless suture. Ventral scutes usually show thicker, more sutural, margins. The dorsal scutes upon the tail lose the peg and groove, are longest in longitudinal diameter, and mostly support a longitudinal submedial ridge on the outer surface; at least in *Theriosuchus pusillus* (Pl. 45, fig. 2).

Genus—NUTHETES, *Owen*.

Species—*Nuthetes destructor*, Ow. Pl. 43, figs. 13—16 and 17—23?

In a former 'Monograph on the Fossil Lacertian Reptiles of the Purbeck Limestones' the above genus and species were founded on portions of jaw and teeth, kindly transmitted to me by Charles Wilcox, Esq., of Swanage, Dorsetshire.

[1] Pls. 7 and 8.

[2] 'Report on British Fossil Reptiles,' 1841, p. 70.

In Mr. Beckles' collection further evidence of *Nuthetes destructor* is afforded by the portions of jaw (Pl. 43, figs. 13 and 14) and by numerous detached teeth, ranging in size from a length of enamelled crown of 5 mm. to 20 mm. (fig. 15, *c*), and with variations in the proportion of length to basal breadth (comp. fig. 15, *d*, *e*, with *a*, *b*).

The teeth in the mandibular fragment accord in size and shape with those of the original or type specimen;[1] they are laterally compressed, strongly recurved, and combine a basal fore-and-aft breadth of 3 mm. with the length of 5 mm. (straight). They likewise show the "excavation or longitudinal depression on the side of the base." The coronal enamel does not extend over this depression, but is continued along its margins, and to a greater extent on that next the convex border of the crown than on the opposite side. In the portion of jaw, originally figured, with seven more or less perfect tooth-crowns, two of these indicate a longer and more slender shape than the rest. Several detached teeth of this type have been exposed in portions of the 'Feather-bed Marl' in the Becklesian series. Some of these, exemplifying difference of size, are figured in Plate 43, fig. 14.

In all these tooth-crowns the characteristic fore and hind finely denticulate ridges are discernible, as shown in the magnified view (fig. 16); the rest of the enamel is smooth and even, as in the type of *Nuthetes destructor*. Of this species I am disposed to regard the specimens above described as indicative of the range of size according to growth of individuals rather than as exemplifying specific modifications of the genus.

Dermal Bones ('granicones').

In many portions of the matrix of the 'Feather-bed' are ossicles of a conical shape, the cone showing various degrees of elevation, with a granulate surface, the base being flat and smooth, or faintly and minutely pitted. These 'granicones' I regard as dermal bones.

In Pl. 43, fig. 18, is represented a 'granicone' with a basal breadth of 8 mm. and a length or height of cone of 14 mm. In fig. 19 the base is oblique, reducing the shortest side of the cone to a height of 8 mm. In this, as in some of the similarly shaped 'granicones,' part of the basal margin is raised or prominent, sometimes formed by a single series of close-set granules, as in fig. 20. Those on the surface of the cone are less regularly disposed, but at some parts affect a longitudinal arrangement (fig. 21.) The apex shows various degrees of obtuseness, which finally reduces the granulate or exterior surface of the cone to a moderate convexity, but the conical shape is the rule. The smallest of such 'granicones' has a basal breadth of 3 mm., a length of 5 mm.

Slices of these enigmatical fossils prepared for the microscope (figs. 22, 23) demonstrated the absence of the structures characteristic of piscine dermal bony cones and spines.

[1] 'Quarterly Journal of the Geological Society,' 1854, p. 120.

Moreover, the geological deposit (a subdivision of the Purbeck series) containing the granicones is a fresh-water one, and their structure was equally distinct from the ganoid dermal defences of the *Sturionidæ* or other fishes habitually frequenting lakes or rivers. The dermal scutes of *Theriosuchus* are notable for the greater number of the canaliculi, and the more regular 'lay,' or disposition, of the 'lacunæ' or bone cells, than in Lacertians; also by the wider 'sinuses' or unossified tracts. In the dimensions, size, shape, and number of the 'canaliculi;' in the minor regularity of the 'lay' of the lacunæ, and in the less proportion in both number and dimensions of the sinuses, the bony tissue of the granicones resembled that in Lacertians; and in this conclusion from microscopical characters,[1] combined with the evidence of the association, and the contiguity of the granicones, with the unquestionable fossil remains of *Nuthetes destructor*, I derive the grounds for referring them to that extinct genus and species.

Among modern Lizards the singular '*Moloch horridus*' of Australia exemplifies dermal scutes most nearly resembling these 'granicones' in shape; but the horny exterior is supported by dense fibrous tissue, not bone. It may be that we have in them a formal exemplification of the dermal armour of *Nuthetes destructor*. If so, the association of a Lizard of such forbidding physiognomy with small Marsupials having their nearest of kin in Australia would be worthy of note.

[1] See 'Journal of the Royal Microscopical Society,' vol. i, No. 5, p. 233, pls. xii and xiii.